METALLURGIA

The British Journal of Metals

(INCORPORATING THE METALLURGICAL ENGINEER.)

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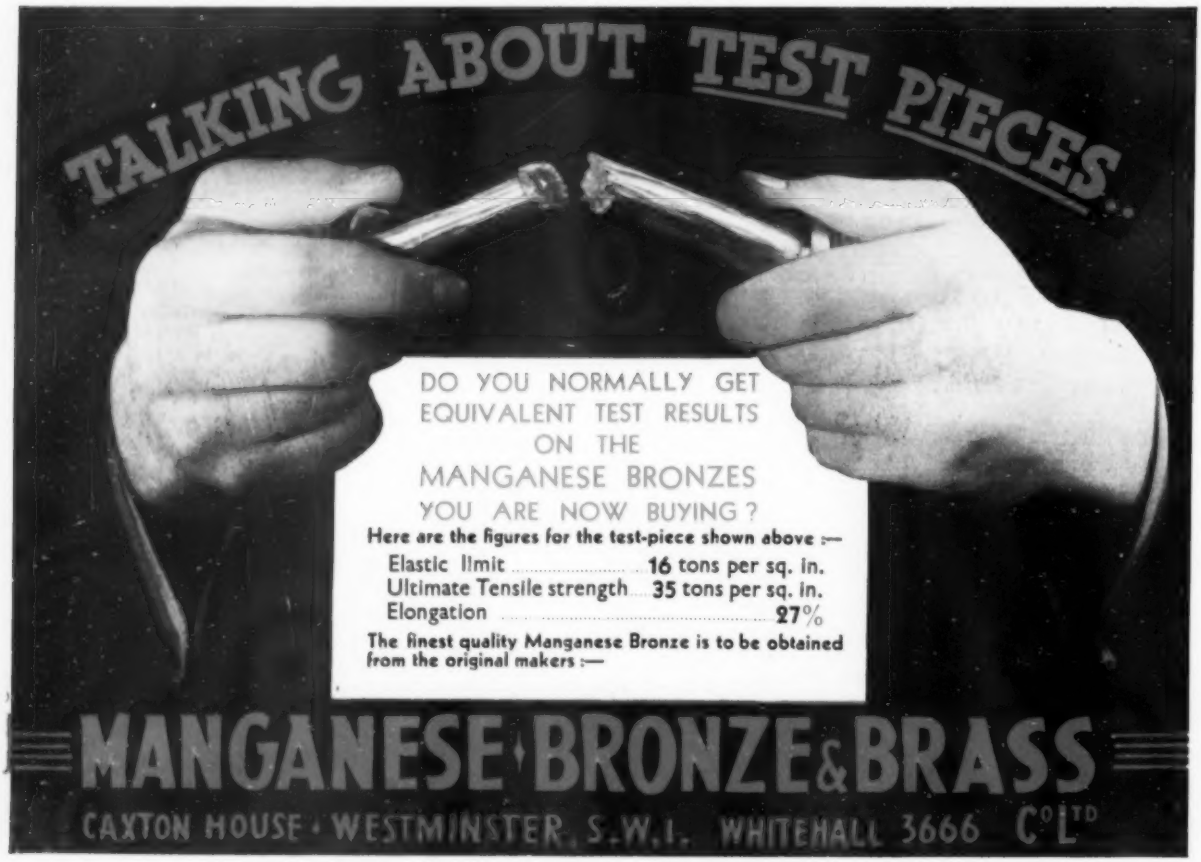
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METALLURGIA

THE BRITISH JOURNAL OF METALS.
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May, 1935. VOL. XII., No. 67.

Progress in the British Iron and Steel Industry.

BY AN OBSERVER.

Despite statements to the contrary, revolutionary developments have taken place in the iron and steel industry during recent years as a result of reorganisation, not all of which is due to outside influences. But the change in the fiscal policy of this country undoubtedly gave producers more confidence to proceed more rapidly with reconstruction schemes.

Blast furnace plant of Barrow Hæmatite Steel Co., Ltd.

FROM time to time certain sections of the press are very critical of the efforts of the iron and steel industry; in addition to imputations of inadequacy or inefficiency, they frequently cast reflection upon the integrity of the industry, asserting that reorganisation is not progressing on anything like the scale expected. Apparently criticism of this type is supported by Mr. Runciman, who, speaking in the House of Commons recently, stated that the iron and steel industry had had to be pushed into reorganisation, though he agreed that it was making satisfactory progress. In fairness to the industry, it should be pointed out that the majority of heavy steel makers in this country had persistently held the view that the industry could not possibly live unless a fundamental change was made in the fiscal policy of the country.

Many factors arising out of the war made the position of the British iron and steel industry one of extreme difficulty, and in making any criticism of its activities some at least of these factors should be borne in mind. Market requirements for its products varied so much that mass production of standard materials could only be adopted to a very limited extent; in consequence, it was not easy to produce with the same high degree of efficiency such as were obtained in foreign works, operating on mass production lines. Another factor which operated to the distinct disadvantage of the industry was the dear fuel period which immediately followed the war. This difficulty was not experienced to anything like the same extent on the Continent. Many plants in these countries were entirely destroyed during the war, and complete rebuilding was necessary, while the inflation policy adopted in certain countries reduced the charges on existing plants to negligible proportions and made it easier to obtain new equipment. Lower wages in these countries, together with depreciating currencies stimulated their capacity, resulting in high fuel and production efficiencies. In Germany, for instance, the deflation in currency enabled industry to obtain cheap labour and materials, and, by borrowing a large amount of capital abroad, she was able to conform to the requirements of the Versailles Treaty and reorganise her industries to meet peace time conditions.

No such compulsion was necessary in this country, and conversion of plant and factories to normal conditions proceeded in a more haphazard way. With the exception of a few outstanding examples, complete reorganisation, to the same extent as on the Continent, was not attempted; it was not surprising, therefore, that in a restricted market British manufacturers suffered. Great Britain faced her responsibilities abroad too readily, and failed to give that attention to domestic problems which were not less important. The stabilisation of the pound imposed a severe strain on the financial structure, which prevented much reconstruction or new installations of plant. Thus, the British iron and steel industry, working with high labour costs, heavy transport charges, and heavy taxation, found its competitive power reduced to such an extent that its competitive efficiency was seriously impaired. There is little wonder, therefore, that reorganisation was not then attempted on a co-ordinated scale.

It is, of course, true that when the industry was eventually given some measure of protection, the primary object was to provide it with the opportunity for reorganisation on lines best adapted to this country and the diversified nature of the demands which have to be met. But there has only been three years available to inaugurate a considered plan of reorganisation of an industry which for ten years had been exposed to unfair competition. At first protection

Coke side of battery of coke ovens installed at the Irlam Works of the Lancashire Steel Corporation, Ltd.

was granted in a very halting manner—*i.e.*, for a limited period. This was subsequently extended, and the stipulation was made that the industry must put its house in order and supply the right material at the right price.

Owing largely to the complex character of the industry and the controversy which resulted from the draft scheme, some eighteen months elapsed before a scheme was approved, but in the relatively short time since it was put into operation remarkable progress has been achieved. Immediately before the Government recognised that this vital industry should have some form of protection, however, strenuous efforts to promote economies in operation were being made by iron and steel manufacturers. The pressure of keen competition at that time necessitated the exploration of every avenue likely to lead to greater productivity efficiency. Plant, equipment, and personnel were critically examined for weaknesses which could be strengthened at an expense that would be more than balanced by more effective and cheaper production, and a good deal of reorganisation was effected.

Attention was then directed to producing units, as it is now, and modifications were being made or were contemplated to blast-furnaces, open-hearth furnaces, and rolling mills, with the object of increasing their capacity and producing on a more economic basis. In some instances entirely new units were designed and constructed. The new blast-furnace at Dagenham is an example, while the Shotts Iron Co., Ltd., Edinburgh, replaced an old-type coal-fired blast-furnace with a new furnace driven on coke instead of coal. A new blast-furnace of outstanding interest, because of its many labour-saving devices, was that built at the Derwent Works of the United Steel Companies, Ltd. Steel-making furnaces were being built, and in many instances these were equipped with automatic control mechanism in order to secure better and more uniform operation. The new open-hearth furnaces built for the English Steel Corporation, Ltd., are an instance of such furnaces.

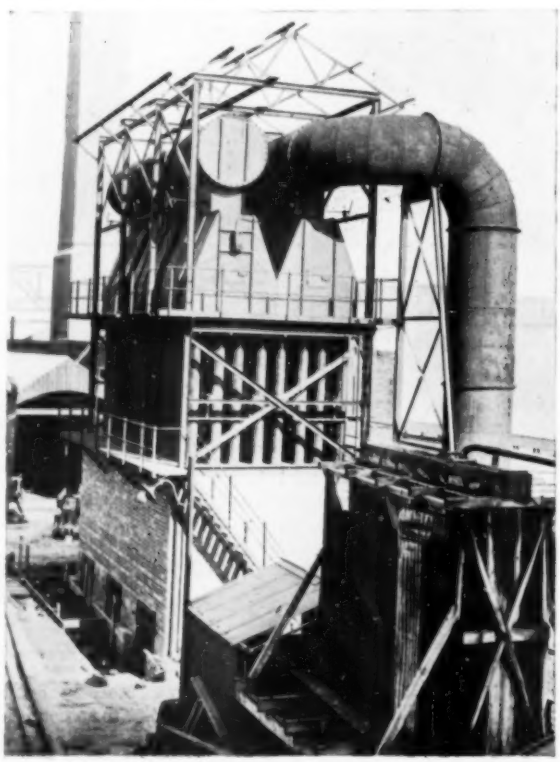
The increased demand for accuracy and improved quality of product as well as increased speed in production necessitated considerable developments in mill design in order to obtain the maximum efficiency in operation, and several mills were re-equipped or modifications made to existing plant, particularly in regard to lubrication, which until recent years was given relatively little consideration. The layout of rolling plant varies according to the material to be rolled, but attention was and is directed to designs which give the most consistent results over the longest period of service with a minimum cost of upkeep. The demand for more power, particularly in regard to heavy blooming and slabbing mills, increased the difficulties experienced in designing the mechanical and electrical parts of the main drive on customary lines, and changes became highly desirable.

Much of the obsolete plant in this country has been replaced by more modern mills. Many reconstruction schemes were completed long ago. Of these may be mentioned the changes effected at the works of Consett Iron Co., Ltd. The type and arrangement of the mill plant at these works, which was constructed by Davy Brothers, Ltd., of Sheffield, is of the most modern character, and is comparable with the best in this country, America, or on the Continent.

Another feature in the operation of the iron and steel industry that is productive of considerable saving is the efficient use of blast-furnace and coke-oven gases. Both from an economic and an operating standpoint the conditions involved in the utilisation of these gases vary with different plants, but much greater attention is being given to the economies that can be effected by making fuller use of these by-products for a multiplicity of operations in the steel plant. This was one of the principal developments in a scheme commenced about the middle of 1930 at the Normanby Park Works of John Lysaght, Ltd. The directors decided to embark on an expenditure at these works which has amounted to close on half a million pounds. It was felt that the Scunthorpe district would be one of the last to be put out of business by foreign dumping, partly by reason of its natural geographical advantages, and partly because at these works John Lysaght, Ltd., had always specialised in the manufacture of steels not easily obtainable elsewhere.

This reorganisation was undertaken in order to reduce costs of production and to increase the flexibility of the plant, to enable the firm to meet individual customers' requirements. It was fully realised that at that time it would have been impossible to rely on the help of any increase in production reducing costs. Rather was a reduction in the volume of production feared. The method adopted was therefore to take the fullest advantage of the geographical position of the works. Fortunately, the

Gas cleaning plant on the latest two-stage principle; one of the installations in the huge scheme of Messrs. Stewarts and Lloyds, Ltd., at Corby Works.

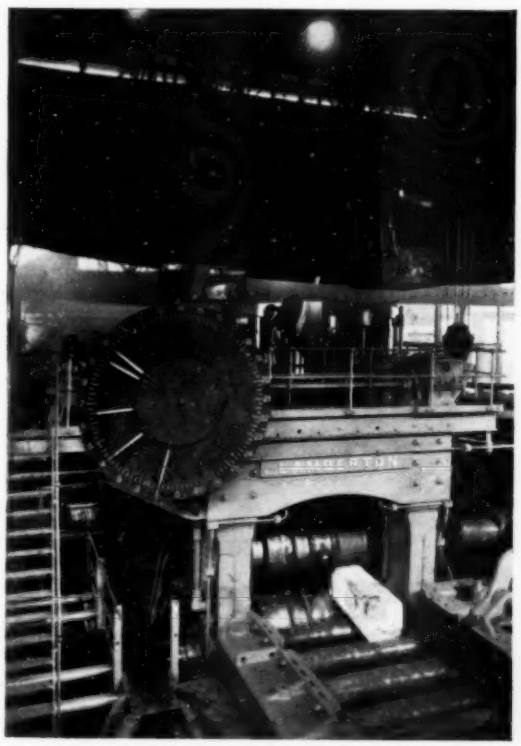


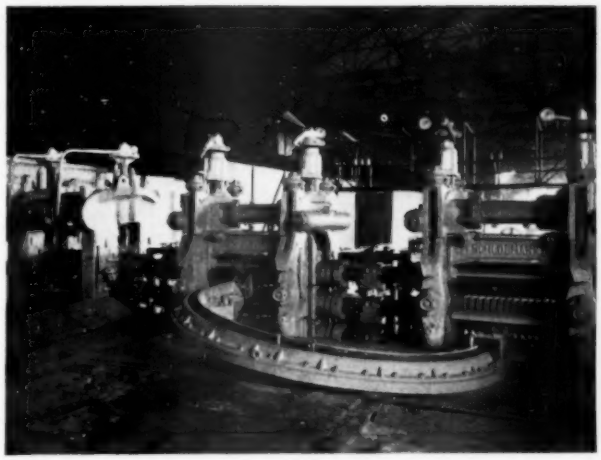
possession of a local ore field simplified matters, which, however, required a considerable quantity of coke for its melting. First of all, attention was directed to coke consumption, and for this purpose a large ore crushing and screening plant was installed. Having obtained this reduction in coke consumption, and improved the regularity of driving of the blast-furnaces, it was estimated that there would be sufficient gas in the coal used to provide the necessary coke to provide all the heat requirements of the works. A battery of the most modern coke ovens was installed, together with gas-holders. A great deal of work was done in improving the thermal efficiency of the various gas-consuming units, with the result that when imports of foreign steel were eventually checked, the plant was in a position to meet the demands made of it, and to produce steel at a cost which compared favourably, product for product, with that produced on the Continent. It is not too much to say, however, that despite the foresight and optimism of the directors of this company, even in the dark days of 1930, most of the capital expended would have been wasted had this country not changed its fiscal policy.

Another company to give attention to the production of cheaper steel in the initial stages of manufacture was the Lancashire Steel Corporation, Ltd. The producers of iron and steel in Lancashire, as elsewhere, realised the advantages possible by amalgamating their interests and modernising and centralising their equipment in order to produce more efficiently and economically. This led to the formation of the Lancashire Steel Corporation, Ltd., over five years ago, and a considerable sum of money has been spent in installing modern machinery at their works at Irlam. One of the most important of these installations is the centralised plant for the production of coke required in the blast-furnaces. This, together with other installations and economies which have been effected in other parts of the works, has revealed the wisdom and justified the courage of the directors in seeking greater efficiency and economy.

In these works the coke-ovens, blast-furnaces, open-hearth plant, and rolling mills are arranged on one site, steel thus being produced from the raw materials to the finished article, and full use is made of the heat in the surplus gases from the coke-ovens and blast-furnaces. From a fuel efficiency point of view, this plant is of outstanding interest. This has resulted from the installation of a battery of 51 Becker ovens, coal handling, washing, blending, and crushing plant, coke screening and handling plant, and by-product recovery plant, including benzol plant for the production of motor fuel.

Cogging-mill at Irlam Works of the Lancashire Steel Corporation, Ltd. It has a capacity of 120 tons per hour.





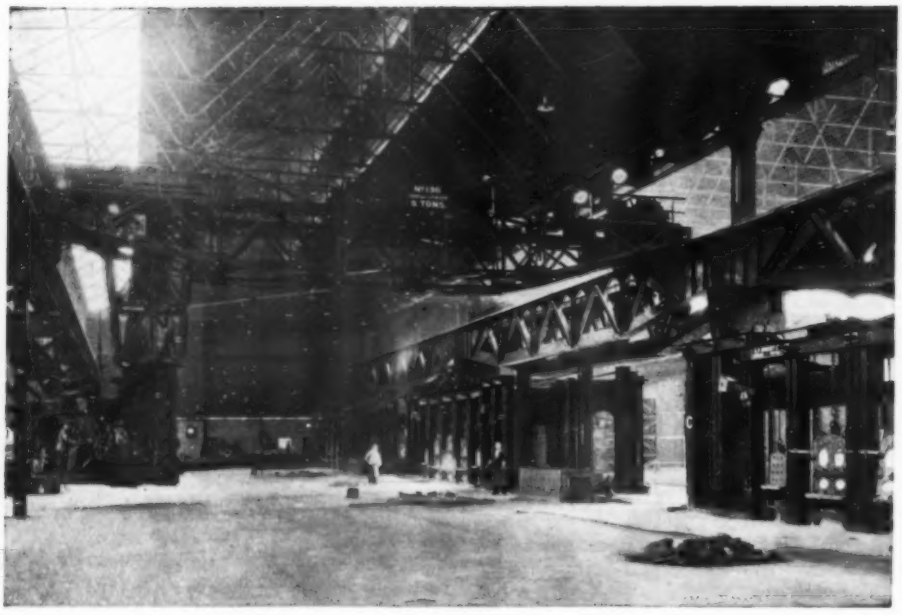
18-in. mill-finishing rolls with repeater at Irlam Works.

The raw coal, much of which is supplied by the Wigan Coal Corporation, Ltd., is received in wagons which pass along the plant sidings to a wagon tippler for discharge into the coal track hopper. From the hopper the coal is delivered by a belt conveyer to the raw coal bunkers, from which it is fed to the coal washery through a dedusting plant. The coal washery is of the automatic Baum type, having a capacity of 175 tons per hour, and is fully equipped with dewatering sieves to reduce the moisture content of the coal.

The washed coal is finally delivered to the blending bunkers, where provision is also made for the further draining of the coals before discharge over revolving tables to regulate the proportion of each class. The mixture of dust originally extracted from the raw coal and the recovered slurry is at the same time added to the blended washed coals in suitable proportion, and the mixture is delivered to the crushing plant, where it is reduced to a finely pulverised state. This is then conveyed by belts to the oven bunker, where accommodation is provided for 2,000 tons of coal.

Readers will be familiar with the comprehensive scheme of reorganisation undertaken when the steel interests of Vickers, Ltd., Sir W. G. Armstrong Whitworth, and Cammell Laird were taken over by the English Steel Corporation, Ltd., in 1929: a scheme which involved new research laboratories, a Siemens melting department, embodying the very latest practice. In addition to these contributions to the scheme, which have been completed, the various machine shops have been entirely rearranged and centralised, and the forge department has been rebuilt and re-equipped with the object of centralising in one department the principal forge plants of the various branches.

With the recent completion of the machine shops, one of the most modern in the country, the English Steel Corporation, Ltd., have spent about a million and a half pounds on this complete scheme of reconstruction and modernisation of their various departments. The new machine shops possess over a mile of bays, which house most modern machines, capable of dealing efficiently and economically with their own products, which vary in weight from a few pounds to well over 100 tons. It will be noted that this firm also was sufficiently optimistic to begin an impressive scheme of reorganisation without Government pressure, and to-day it is able to meet the rapidly expanding



General arrangement of the Siemens melting department at the Vickers Works of the English Steel Corporation, Ltd.

fields of activity in which steel plays so important a part. The concentrated effort and scientific knowledge available, and the collaboration between the melting plant and the metallurgical and research departments characteristic of these works, together with the modern plant and equipment, facilitates the manufacture of the highest grades of carbon and alloy steels.

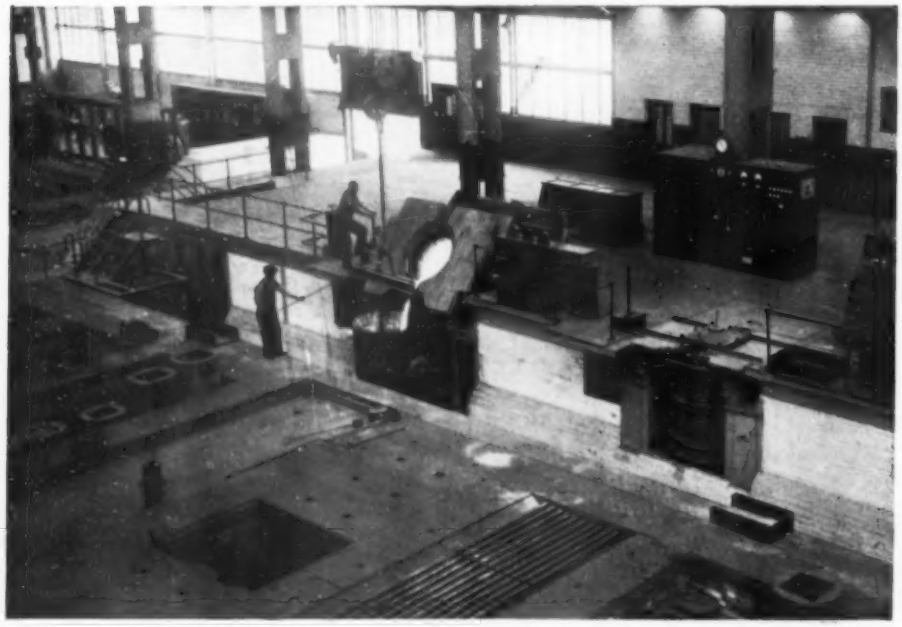
Another combination of firms to be congratulated on the progressive policy adopted are those embraced by United Steel Companies, Ltd. This scheme also was inaugurated some years ago, when trade was probably at its worst. In addition to the blast-furnace, to which reference has been made, mention should be made of the high-frequency melting installation, which is claimed to be the largest of its kind in this country. From a laboratory curiosity of only a few years ago, such rapid progress has been made with this type of furnace that many experts regard it as the most efficient for super-quality steels. As a melting unit, the value of the high-frequency furnace is now established, but it is proving remarkably useful also as a refining unit. It has been proved that carbon, manganese, sulphur, silicon and phosphorus can be removed from the melt if desired. Another important aspect is the degree of control over the content of dissolved iron oxide, and of dissolved gases.

Amongst the many other developments of this progressive company, the building and equipment of the central research laboratory are not the least important. This laboratory is one of the most advanced of its kind, and is an indication of the faith of the directors in the recovery of the British iron and steel industry. The steps taken by the directors before there was a likelihood of a change in the fiscal policy showed that they were not content with inadequacy or inefficiency, nor were they indifferent under the great economic difficulties through which they and the country were passing at that time. That success has rewarded their foresight is indicated by the fact that production is proceeding on record lines in order to satisfy increasing demands for the products of their various works.

The large-scale venture by Messrs. Stewarts and Lloyds, at Corby, in Northamptonshire, is another development about which it would be distinctly unfair to state Stewarts and Lloyds were pushed into. The directors of this company for a number of years recognised the great potential value of the Northamptonshire deposits of iron ore, which, by adopting a suitable process, would enable steel to be produced at a cost comparable with that of Continental steel The results of full-scale experiments and exhaustive trials convinced them that this ore is particularly suited for the manufacture of steel by the basic Bessemer process, and steel-making plant of this type is being erected at Corby, in Northamptonshire. The results of this venture will be watched with more than ordinary interest, not only by steel manufacturers in this country, but by those abroad, particularly on the Continent. Certainly Messrs. Stewarts and Lloyds deserve congratulations for their courage in developing a scheme of such importance at such a critical time ; it showed a confidence in the British iron and steel industry at a time when pessimism prevailed.

But many more large-scale developments could be reviewed in a similar way. Mention could be made of the

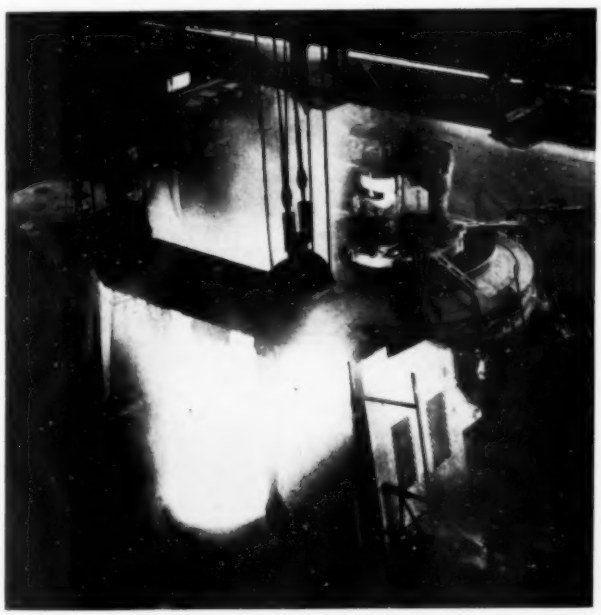
A general view of the high-frequency furnace installation at the Stockbridge Works of Samuel Fox and Co., Ltd.



reorganisation and reconstruction at Messrs. Thomas Firth and John Brown, Ltd., Messrs. Colville's, Ltd., to developments of the industry in the South Wales area, and many smaller but important schemes of reconstruction and re-equipment. These examples, however, suffice in showing that manufacturers are not less progressive and courageous than formerly, that they possess those characteristics of leaders of the industry in the past, and will, with reasonable support, restore the British iron and steel industry to the position of eminence it formerly occupied in the world's markets.

It is not suggested that reorganisation and reconstruction in the industry is complete; it is doubtful whether it will ever be, but it is distinctly unfair to state that pressure had to be brought to bear upon these firms to facilitate a progressive move. The truth is that at a time of great national adversity they took great financial risks to install the most modern plant and equipment in order to place their works in a position to meet changed industrial conditions.

One of the bays of the new machine shop at the Vickers Works of English Steel Corporation, Ltd.



Large electric furnace installation at the works of Thos. Firth and John Brown, Ltd.

Conference on Corrosion.

THE annual conference of the Working Association for Combating and Preventing Corrosion, of which the Society of German Chemists (Verein deutscher Chemiker e.V., Berlin W 35, Potsdamer Str. 103a) has the secretarial direction for this year, will be held at Berlin, on Monday and Tuesday, November 18 and 19, 1935. The subject chosen for discussion is "Corrosion from Water," the damage caused by corrosion from water being regarded, probably, as of the most serious consequence economically. In connection with this subject, the exceedingly important question of corrosion from salt sea-water will also be discussed.

Exploitation of Kursk Magnetic Anomaly.

THE first mine sunk on the base of the Kursk Magnetic Anomaly will start working this month, and iron ore will be obtained from these deposits—the richest in the world. The starting of the first iron ore mine in this region will be of great significance for the creation of a new iron ore base in the centre of the U.S.S.R. The Kursk Magnetic Anomaly long ago attracted the attention of scientists, and the history of their investigations are of the greatest interest.

Sharp deviations from the earth's normal magnetism were noticed in 1874 on a long and narrow strip of land (about 150 miles) across the territory of the present Kursk and Voronezh provinces. As is known, the earth possesses the properties of a magnet, the poles of which approximately coincide with the geographical poles. That is why the magnetic needle of a compass points towards the north. But in the Kursk area the magnetic needle does not "behave normally," showing thereby that there are large deposits of some magnetic material in this part of the earth's crust which prevent the normal function of the compass. In the force of these deviations, the Kursk area exceeded all existing anomalies of earth magnetism in the world. Professor E. Leist studied this anomaly for 21 years, from 1896 to 1917, resulting in the discovery that immense quantities of iron ore are deposited in this area.

After a lapse of a few years, on the proposal of Lenin, exploration of the Kursk Anomaly was started. For this purpose a special commission was formed by the Supreme Council of National Economy in 1919. Deep drilling revealed deposits of iron ore at a depth of 120 m. to 150 m., which, on a provisional estimate, showed indications of very extensive deposits.

At the last meeting of this supervisory council, Pripor, head of Kramstroi, reported that shaft No. 1 had already been sunk 140 m., and that the pit will be entirely completed by the end of the year. Simultaneously, work has commenced on sinking shaft No. 2. A branch line is being laid from the mine to the main railway (a distance of about five miles) which was completed in January, this year. Analysis of the samples taken from the mine workings has shown that the ore of the Kursk Magnetic Anomaly is of avery high quality, the average iron content amounting to 64%, with a low content of sulphur and phosphorus.

Metals and Alloys— Their Atomic Arrangement

The crystalline state of materials is of great importance to a large number of sciences, and in the recent Annual May Lecture before the Institute of Metals, Professor W. L. Bragg, F.R.S., gave an account of some of the developments which have taken place in examining solid bodies since his father, Sir William Bragg, discussed the subject before the Institute in 1916. The lecture is reviewed briefly in this article.

THE great technical importance of metals and alloys makes any contribution to a knowledge of their fundamental structure a matter of great importance. It is now generally recognised that the crystalline state of materials is of importance to a great number of sciences, particularly as a result of the introduction of X-ray methods of examination, the development of which has been responsible for astonishing progress and discoveries about the structure of metals.

In this lecture, Professor W. L. Bragg dealt with the inner structure, or atomic arrangement, of metals and alloys; he said X-ray analysis has given us a new method for examining solid bodies, because by observing the way in which these rays are scattered or "diffracted" by the regular pattern of a crystalline solid, the arrangement of the atoms in a solid can be deduced. The new discoveries about the structure of metals made by X-ray analysis formed the subject of the May Lecture given by his father, Sir William Bragg, to the Institute of Metals in 1916, and in this lecture Professor Bragg gave an account of some of the developments which have taken place since that date.

Three main features of structure may be distinguished. There is first the atomic arrangement in single crystal grains of a homogeneous alloy which is in a state of equilibrium. There is, in the second place, the nature of the arrangement in an alloy which is not in equilibrium, but has been obtained in some other state by the quenching and annealing processes which are so widely used to give the alloy desirable properties. In the third place, there is what may be termed the "geography" of the alloy. By this is meant the shape and size of the crystal grains, their orientation relatively to each other, and the way in which blocks of the various different crystalline phases fit into each other if more than one is present. All these factors are of importance in determining the properties of the alloy, and all can be examined by X-ray methods.

In so immense a subject Professor Bragg confined himself to certain features; he limited his discussion to the first two factors described above. The third factor is of equal or even greater importance, but it is not so amenable to theoretical treatment, and he wished to show how the new knowledge of atomic arrangement could be made the basis of a theory, at any rate in outline, of alloy structure.

In general, when one metal is alloyed into another a series of phases appear. Metal A dissolves a certain amount of metal B with a gradual alteration in properties as the proportion of B increases. At a certain composition a limit is reached, and for greater amounts of metal B a new phase appears as separate crystals of quite different properties mixed with the first phase. Their relative amount increases till the whole structure consists of the new phase. Regions of single and double-phase alternate as the composition varies from pure A to pure B. These phases are the nearest approach in an alloy system to the chemical compounds formed by combining elements. X-ray analysis has shown that each phase has its own definite pattern, such as a cubical array with atoms at corners and centres, or at corners and centres of faces. The pattern changes from phase to phase. One of the most interesting of recent contributions has been a theory put forward by H. Jones, which indicates the factors determining the type of pattern in each phase. The theory is only tentative and approximate, but it gives for the first time a reason for one of the most striking generalisations about alloy patterns to which X-ray analysis has led us. This is the empirical Hume-Rothery rule, which states that the ratio of free electrons to atoms in a structure is the same for alloys with the same pattern. Jones has shown how the alloy pattern affects the binding energy of these free electrons, and so has given a reason for the Hume-Rothery rule.

Another point brought out by the X-ray analysis is that the method of arrangement of the atom amongst the positions of the phase pattern can be varied widely. The phase pattern is an entity apart from the way the atoms are distributed, in marked contrast to ordinary chemical compounds. The study of the movements of the atoms amongst the positions, as affected by heat-treatment, can be made the basis of a very interesting theory. At high temperatures the atoms are shuffled up in a random way, at low temperatures they sort themselves out into a regular alternation. The course of the transformation as temperature varies, its rate of attaining equilibrium, its influence on the specific heat and electrical resistance of the alloy, and many other features can be predicted theoretically and agree with experiment. These transformations explain many hitherto puzzling features of alloy phase-diagrams.

The importance of all this work is that it provides a basis for the chemistry of compounds formed between metals. Although an immense amount of knowledge about the properties of metals and alloys has been won, it is perhaps fair to say that a fundamental basis of this kind has hitherto been a real need. The determination of the arrangement of atoms in chemical compounds has caused us to view many of the generalisations of chemistry in a new light, and this has been conspicuously the case in metallurgy.

The Spectrographic Analysis of Aluminium.

In continuation of the programme of standardisation of spectrographic methods, a paper before the recent meeting of the Institute of Metals, by D. M. Smith, B.Sc., deals with their further application to the quantitative spectrographic determination of the usual impurities in pure and commercial brands of aluminium.

Ordinary photographic records of arc and spark spectra of graded series of standard alloys of aluminium with copper, iron, manganese, silicon, and titanium, have been investigated from the point of view of the establishment of a satisfactory routine method of analysis. The spark gives a steadier and more reproducible source of light, and since adequate sensitivity of detection of the impurities usually occurring in aluminium is obtained, analytical tables have been compiled for use with the spark method. For routine testing of samples an auxiliary alloy of aluminium with 1% nickel is used for the auxiliary spectrum method, but further accuracy of determination would be obtained by direct comparison with suitably selected standard samples. The arc method is more sensitive for the detection of traces of such impurities as lead and gallium.

METALLURGIA
THE BRITISH JOURNAL OF METALS.
INCORPORATING "THE METALLURGICAL ENGINEER"

Growing Confidence.

The Jubilee, the British Industries Fair and Improving Trade.

THE British Industries Fair of 1935 is being held under a clear sky. This country has again proved not only its wonderful resources and incomparable financial stability, but the native grit of its people. England has again become a leader among the nations. There has been industrial upheaval throughout the entire world during the post-war years, and there has been too great a tendency to subscribe to the opinion that England is no longer the work-shop of the world. The interferences with export trade have been and still are deplorable, but extreme nationalism, either in the political or industrial spheres, will be a passing phase, and although some industries will never again attain former dimensions, we can and must hold our position as the leading manufacturing country. At Castle Bromwich there is plenty of evidence of British enterprise and virility, but it is not necessary to go there to have proof of this. There has been a stirring even in the depressed areas, a revival of hope. In most of the big industrial centres unemployment is decreasing, and there is growing confidence that the trade improvement is of a more rather than less permanent kind. This confidence is shown in an increased disposition to take reasonable business risks, thus we are gradually getting away from hand-to-mouth buying. The spontaneous outburst throughout this country which was shared by the depressed districts on the occasion of the King's Jubilee was a sort of Thanksgiving. The people of this country are reaping a reward for holding on to all that is best in their traditions. There is wisdom in the conviction that institutions and customs that have weathered the storms of centuries should not be discredited and cast aside in exceptional times.

The Fair comes so close after the Jubilee as to give what may be termed a pointed interest to it. There is a natural tendency to reflect on the technical progress that has been made in the metallurgical world during the past twenty-five years. In that period alloy steels have come more and more into prominence, important research work has taken place in the domain of brass and bronze, and aluminium and magnesium alloys have made aeronautical engineering possible. The engineer and the metallurgist have worked side by side to achieve this progress. It has been a great era, and even now it may be that we are just on the threshhold of a greater. It is well at times to dwell on this fact of progress, and forget temporarily the tragedy of the Great War and the shadow of future wars. At Castle Bromwich much that is on view represents the scientific research and manufacturing progress of the last twenty-five years. It can be stated unequivocally that this country is in the vanguard of progress. It is not necessary to go to continental countries or to America for new political systems or different manufacturing methods.

The ferrous and non-ferrous sections of the metal industries have no occasion to reproach themselves for lacking enterprise. There has been too great a disposition in certain ill-informed quarters to declaim against them as being satisfied with obsolete equipment and out-of-date methods. This has been the result of prejudice born of ignorance. As stated on another page, long before there was serious consideration of the imposition of tariffs for the iron and steel industry, that industry was putting its house in order; perhaps it would be more correct to say that it was keeping its house in order. There are still newspapers that—in the alleged interest of steel consumers—condemn the tariff. The best reply to them is that it is since the imposition of the tariff that not only the heavy industries, but those other industries that are the principal consumers of steel have made the greatest strides to recovery. It is not only Sheffield that has increasing prosperity to-day, but the Clyde, the Tyne, the Mersey, and Barrow. With the exception of textile machinery manufacture, there is not a section of engineering that is not in a more prosperous condition to-day than at any time in the past ten or twelve years. And engineering is increasingly prosperous because all industries are recovering. The Chancellor of the Exchequer was justifiably optimistic, and probably nearly correct when he said that we had recovered 80% of our prosperity. We can again refer to Board of Trade figures without fear. Exports are greater than a year ago, and the gains are nearly all accounted for by manufactured goods. In March, iron and steel export increased by £146,855, machinery by £735,949, and vehicles by £860,271, so it would appear that in a world beset with all kinds of restrictions on international trading we are still able to export. "World trade is being steadily dried up," says the annual report of the London Chamber of Commerce. Perhaps so, and if so the fact that our exports are increasing is all the more encouraging. If England loses faith in recovering its export trade, then it would be folly to have British Industries Fairs.

This country is all for freedom in trading, and it can be fairly argued that it was because of this, and not in spite of it, that a steel tariff policy was decided upon. The British steel industry has decided to accept the terms offered by the Continental steel cartel. For three months imports are to be stabilised at the rate of 643,000 tons per annum, and the tariff on the imports from the cartel countries is to be reduced from 50% to 33⅓%. As a result, it is possible that the duties on imports will be reduced shortly. A definite indication of the Government's attitude was given by Mr. Walter Runciman, President of the Board of Trade, when, referring at the annual dinner of the Iron and Steel Institute to the arrangement with the Continental steel cartel, he said: "Under this agreement the very high rate of duty is not so urgently needed. We are prepared under the advice of the Import Duties Advisory Committee to ask Parliament to reduce the import duties. I hope we shall be able to reduce them so long as the cartel is prepared to treat us reasonably."

The iron and steel industry has earned its success. And so does the engineering industry as a whole deserve to have a long period of prosperity. With the King's Jubilee and now the British Industries Fair following it closely, it is almost as though we were entering a New Year of British Industry.

Although this thought may extend the imagination, it is a happy one, for there are distinct indications that the forces of recuperation are bursting the bonds of artificial restrictions of the world's trade, and British manufacturers and producers may reasonably expect the results of the Fair at Castle Bromwich to facilitate the further recuperation of industry. The rekindled hope, which is apparent, will promote greater confidence, and the recovery index will show further improvement and that 20% will diminish.

Silumin-Gamma.

IN cast aluminium alloys of definite composition precipitation hardening can be brought about by heat-treatment, resulting in a considerable improvement of the strength properties. The process consists in producing, by annealing and quenching, a supersaturated solid solution, and reducing same to an equilibrium condition by tempering. The solid solution is the more supersaturated the higher the annealing temperature, and the more drastic the subsequent quenching is. The annealing temperature is dependent upon the melting point of the low-melting constituents of the alloy, and lies between 525° and 560° C., according to composition. Quenching from these high temperatures in water results in setting up stresses in the quenched part, which may lead to the formation of cracks in the case that the alloy does not possess the requisite toughness. Generally, castings do not stand a rough quenching treatment, because of the coarse casting structure, wide variations in section, and complicated shape. A full improvement of the strength properties by heat-treatment is, therefore, only possible in castings of simple design, which is of little practical value. In the majority of cases one is compelled either to forego the heat-treatment entirely or to render the process less drastic by decreasing the annealling temperature and quenching the castings in hot water or oil.

As Dr. J. Dornauf states in the September issue of *Aluminium*, a new aluminium-silicon alloy, called silumin-gamma, has been recently developed which can be fully heat-treated in the cast state, irrespective of size and shape of the castings. Like the well-known alloy, silumin, the new alloy consists of a eutectic mixture of aluminium and silicon, with small additions of manganese and magnesium, which, however, do not interfere with the eutectic character of the alloy. The new alloy has, therefore, all the properties of silumin, such as good castibility, high corrosion resistance, and great toughness. Owing to the eutectic composition silumin-gamma has practically no freezing range and is, therefore, tough immediately after becoming solid. It can, therefore, be heated to just below the melting point of the magnesium-silicide compounds, and quenched from this temperature in cold water. Before being heat-treated the new alloy is called silumin-beta, in order to avoid mistakes in the foundry. Shortly before pouring the alloy is modified by adding metallic sodium. Modifying salts should not be used as they eliminate the magnesium. The alloy can be cast in sand, and used as gravity and pressure die-casting alloy as well. When cast in sand it is advisable to make ample use of chills at the larger sections of the castings in order to accelerate solidification and get a dense structure.

The heat-treatment consists in annealing the castings at 530° C. for 3 to 4 hours, with subsequent quenching in cold water. Tempering can be carried out at any convenient time by heating the parts to 150° C. for 20 hours. Under favourable casting conditions the structure of gravity die castings is such that annealing at 530° C. can be dispensed with, and by mere tempering strength figures can be obtained which equal those of fully heat-treated castings. Pressure die castings need only to be tempered. For the heat-treatment operation only furnaces should be used, the temperature of which can be kept constant within ± 5° C. When by improper handling during the quenching operation the castings distort a little they can be easily straightened prior to tempering. Working the heat-treated alloy with cutting tools does not release any stresses, and, hitherto, not the slightest distortion could be observed in finished castings.

Separately cast test-bars of silumin-gamma show the strength properties recorded in Table I. Test-bars cut from sand castings of regular production weighing over 1 cwt. showed that the difference in strength between casting and separately cast bar is only slight, and that the same figures can be obtained when ample use of chills is made. On a 20,000,000-cycle basis the endurance-bending strength was found to be 5·4 tons per sq. in. with sand-cast bars, and 7 tons per sq. in. with chilled bars. In the repeated impact test a sand-cast bar with a circular groove sustained 600,000 blows until fracture occurred, compared with 40,000 blows sustained by the heat-treated Y alloy. Silumin-gamma has also a high creep limit. Due to its good strength properties, coupled with low weight, it will find wide application in the manufacture of Diesel and aero engines.

TABLE I.

STRENGTH PROPERTIES OF SILUMIN-GAMMA.

Casting Method.	Tons per sq. in. 0·2% Stretch Limit.	Tons per sq. in. Tensile Strength.	Elongation, %	Brinell Hardness.
Sand	11·4 to 16	16 to 18·4	4 to 0·5	80 to 100
Gravity die	12·7 to 17·8	16·5 to 20·3	1·5 to 0·5	85 to 110
Pressure die	—	19 to 23·5	1 to 1·5	110 to 130

Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys.

THE development of the so-called " stainless " steels, which presented numerous problems and handicaps, has been among the outstanding metallurgical accomplishments of recent years. As the result of the wide application of these stainless metals, there has been an increasing need for standard specifications and tests.

This matter has been the subject of considerable study by Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys of the American Society for Testing Materials. At a recent meeting of this Committee considerable progress was reported in the formulation of purchase specifications for the chromium- and nickel-bearing steels for which the Committee is responsible. The Committee expects to be able to present to the Society in June five new specifications which will cover the annealed corrosion-resistant sheet steels, both plain chromium and chromium-nickel steels, and also for cold-rolled chromium-nickel steel. Drafts of the specifications were considered in detail by a sub-committee, and a number of improvements and changes were agreed upon before they were presented to the main Committee. These specifications will be the first for these materials prepared by the Committee, and represent a significant trend in its work.

The Sub-Committee on Specifications for Castings also completed three new specifications for plain chromium-steel castings which were presented to Committee A-10 for presentation to the Society for publication as tentative. This Sub-Committee also reported that six additional specifications for steels containing chromium and nickel were well under way. The Sub-Committee on Mechanical Tests has prepared an extensive programme for testing both annealed and cold-drawn nickel-chromium steel, especially the 18% chromium, 8% nickel types, with a view to determining the applicability of the existing A.S.T.M. standard methods. The Committee is planning to undertake a co-operative test programme to study methods of mechanical testing and their use for these types of steels.

The Sub-Committee on Corrosion Testing has been giving consideration to the possibility of undertaking atmospheric exposure tests of metals in the field of Committee A-10 work. These would be carried on simultaneously with laboratory tests, using procedures developed, or being studied, by the Sub-Committee. The programme also comprises work to improve the test methods previously studied by the Sub-Committee, which included the salt spray test, the boiling nitric acid test, and the copper sulphate stain test. Consideration is to be given to an electrode potential test, half-tide sea-water immersion tests of refinished salt spray specimens, and to further study of the copper sulphate test with respect to effect of surface finish on reproducibility of results. Ability to detect adverse heat-treatment of corrosion-resisting steels by this test, and the effect of variation of solution concentration upon the results are also to be studied.

Use of Electric Furnaces in Industrial Heat-Treatment

Part III.

By A. GLYNNE LOBLEY, M.Sc.

In the previous articles (January and March, 1935), the author reviewed batch type and mechanically-operated continuous furnaces respectively. In this article he reviews the advances made in bright annealing and clean hardening.

PROBABLY the most striking advance in electric furnace practice is in the application of the electric furnace to bright annealing. It is true that bright annealing of some metals, particularly steel, has been common practice with fuel-fired furnaces for many years. In some cases this older method, which involves the use of boxes, was successful in obtaining a clean unoxidised surface, but in others it only reduced and did not prevent discolouration of the surface. Not only, then, was this method in most cases imperfect in its results, but as it involved the use of heavy boxes it was uneconomical, cumbersome, and slow.

In the electric furnace the production of heat is independent of the nature of the atmosphere and does not necessitate flues or other ventilation, so that the maintenance of an artificial atmosphere in the heating chamber itself is therefore possible, without resorting to the use of boxes. It is true that in the case of certain types, containers are used with electric furnaces, but as these have not to withstand the localised high temperature of a flame, and the action of deleterious agents, such as sulphur, which are present in fuel gases, they may be made of thin sheet of comparatively small heat capacity. In general, great advances have been made in bright annealing owing to the fact that with the electric furnace the atmosphere may be controlled with an exactness hitherto impossible.

Owing to the inherent flexibility of the electric furnace, many ways are possible of combining treatment in a controlled atmosphere with electric heating. A considerable amount of development work has taken place, and is still in progress in developing different types of electric furnaces for the bright annealing of various metals, and in the design of apparatus for producing gases suitable for providing the necessary atmosphere.

Batch and Continuous Types.

The different types of bright annealing electric furnaces may be divided into two main categories: those dealing with the material in batches, and those in which it is handled continuously. One of the earliest types, which is still used for certain purposes, is the pit furnace. In this the material, usually in the form of coils, is loaded into the furnace, which is provided with heating elements radiating directly on to the charge, and covered with a gas-tight lid. The furnace is then heated up to the required temperature and maintained at that temperature for a sufficient time to heat the material uniformly throughout. The furnace and charge are then cooled until the temperature is low enough for the charge to be brought into the air without ill-effects. Before heating, the furnace is thoroughly purged with a protective gas, and the flow of gas is maintained throughout the whole operation. This method is necessarily slow and somewhat wasteful, in that the furnace itself has to be heated and cooled each time. It is used where very slow cooling of the charge is essential, as when dealing with high carbon steel. Since it is only necessary, as a rule, for the cooling to be slow at first, such furnaces are often provided with means for accelerating the cooling in the later stages. This may be done by blowing cold air through tubes which pass through the furnace. In one case the heating elements are made in the form of tubes

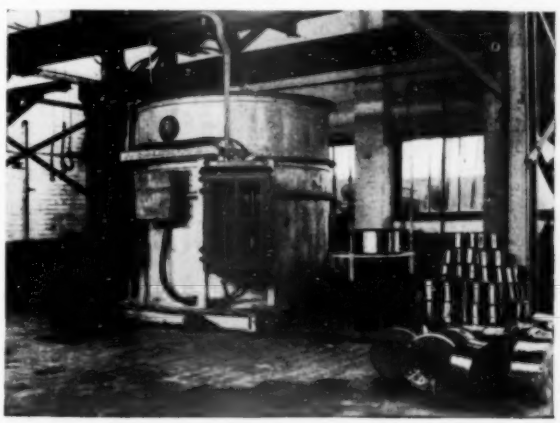
Fig. 1.—40 k.w. bell-type furnace for bright annealing wire. Hearths mounted on turntable.

through which air is blown during the cooling cycle; in others, water-cooled pipes, fitted with air-tight glands, are pushed down the centre of the furnace inside the coils when the cooling is desired. During the heating cycle, these tubes are outside the furnace. In the treatment of some materials it is important that the rate of cooling should be under control, and means are now available for controlling the heating and cooling as well as the final temperature, so that the time-temperature curve follows a definite and prescribed contour.

Bell-type Furnaces.

In order to overcome the loss of heat and production in heating and cooling the whole furnace each time, another method is in use. In this the charge is placed on a hearth and covered with a thin heat-resisting hood which is sealed at the bottom with water or oil. The hood is then purged

Fig. 2.—Water-sealed furnace for bright annealing copper wire.



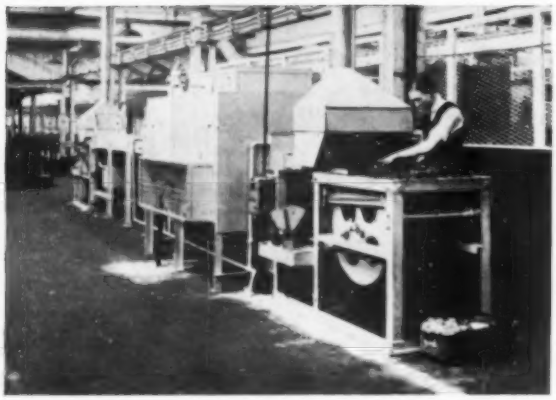


Fig. 3.—55 k.w. continuous belt conveyer furnace for bright annealing stud pressings.

with a protective gas, and the furnace, which is like an inverted pit furnace, lowered over it. From its shape, this type is known as a bell-type furnace, and an example is shown in Fig. 1. After the charge has been properly heated the furnace is removed and placed over another similar charge, and in this way the heat stored in the furnace is not lost. Since it takes longer to cool than to heat a charge and its hood, a number of these hearths or bases are usually provided. The arrangement of furnace hearths can be varied in several ways. The hearths may be mounted on a turn-table as in the illustration, and the furnace merely lifted up and down, or the hearths may be fixed, and the furnace moved from one position to another by a crane. A further modification is to have the furnace fixed in an elevated position, and the hearths mounted on bogies. The bogie, loaded with the charge and covered with a hood, is placed under the furnace, then elevated into position with a hydraulic ram.

Silicon-iron sheets for electrical purposes are often treated in a hydrogen atmosphere in a rectangular pit or elevator type furnace. The sheets are allowed to cool in the furnace, no hood being used. In this instance, however, the object is not primarily to obtain a bright anneal, but to improve the magnetic properties by reducing the carbon content, the carbon combining with the hydrogen to form methane.

Bell-type furnaces for low-temperature operations, such as the annealing of copper, are commonly provided with fans to increase the rate of heating and to improve the uniformity of temperature. The use of these fans also accelerates the cooling. Further developments in this direction may be expected.

All these furnaces are operated with a special atmosphere, the production of which is referred to later. The composition of the atmosphere depends on the metal which is being treated. There is, however, a type of pit furnace using a container in which no externally added atmosphere is used, a little oil on the work serving to remove the oxygen during the heating. During cooling, ingress of air is prevented by a valve, so that the charge is cooled in a partial vacuum.

Fig. 4.—Installation of two continuous belt-type furnaces for bright annealing non-ferrous sheet, the larger one having a belt 4 ft. 6 in. wide.

Water-sealed Furnaces.

A well-known type of fuel furnace uses a water seal, and this has its counterpart in an electric furnace, where the material is charged through water, and quenched on discharge through water. In the case of the electric furnace, no retort or muffle is used. With this process a steam atmosphere is used, steam being added from an external boiler. A large safety valve is also provided to cope with the sudden evolution of steam when the charge is quenched. A furnace of this type is illustrated in Fig. 2, and is used chiefly for the annealing of heavy copper wire. It is not suitable for thin wire owing to the difficulty of quickly drying the treated material, and therefore for fine wire the dry process is much more suitable. With heavy wire the charge rapidly dries without staining. The advantage of this quenching process lies in the large output per unit floor space which may be obtained, as there is no waiting for cooling.

It will be noticed from the illustration that two hearths are provided, these being mounted on hydraulic rams. In the raised position one charge is in the furnace, whilst the other hearth is available for loading and unloading. After the charge has been heated it is slowly lowered into the water, together with the new charge on the other hearth, and when completely lowered the furnace is moved on wheesl over the new charge, and the hearth again raised, so that the first charge is brought into the furnace whilst the quenched and treated charge is brought into the air for unloading.

Fig. 5.—100 k.w. driven roller hearth furnace for bright annealing non-ferrous tubes.

There are other designs of furnaces, including continuous ones, using a water seal, but as very few metals can be bright annealed in a steam atmosphere, the method is somewhat limited in its application. Moreover, the now very successful dry processes, with their many advantages, tend to supplant the wet process more and more.

With the exception of the silicon-iron treatment furnaces, practically all the batch-type furnaces are used for the annealing of coiled material, wire or strip, that is material in comparatively bulky and heavy masses. Wherever possible—that is, where the material is in small units—it is obviously preferable to treat it continuously.

Continuous Furnaces.

In the continuous furnace the time factor is controlled as well as the temperature, and the rate of heating and cooling being greater, grain growth may be avoided or controlled. Moreover, the electrical load is much more constant, with a high load factor, which often means that the electrical energy may be purchased more cheaply. Incidentally, it

might be remarked at this point that the power factor of resistance furnaces is practically unity, and in many cases so raises the power factor of a factory that condensers are unnecessary, whilst at the same time the load factor of het factory is also raised, so that an electric furnace load is a very desirable one, and that of continuous furnaces still more so.

Continuous furnaces themselves may be divided into two categories. One deals with material which is in the form of units, such as sheets, tubes, pressings, small coils, etc. Several methods of conveying this material are used, the chief being the wire-mesh belt-conveyer, the pusher (usually with trays), and the driven roller hearth. In the other one, often known as the single-strand type, the metal is passed through in the form of a continuous strip or wire, and this method is used both for steel and non-ferrous metals. It is somewhat limited in its application, as obviously only the manufacturer of wire or strip is likely to be able to use such furnaces.

Wire-mesh Belt-conveyer Furnaces.

The type of conveyer depends on the form of the material, and other local conditions. Where the material is in the

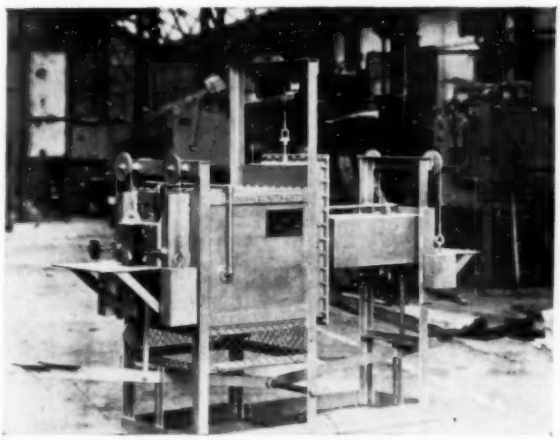


Fig. 6.—A small semi-continuous furnace for bright annealing small parts.

form of pressings, sheets, light coils, etc., the wire-mesh belt is usually the most convenient. Such a furnace, used for the annealing of steel pressings, is illustrated in Fig. 3, where the operator is seen placing the charge on the belt. The furnace illustrated has a rating of 55 k.w., and is capable of an output of 300–400 lb. per hour. The belt is continuously moving, the speed adjustable to the size and weight of article being treated, carrying the material through the heating chamber and then through water-jacketed compartments, so that it is completely cooled before emerging into the open again. The whole furnace is provided with a special atmosphere, slowly escaping at the two ends to prevent the ingress of air. The amount of gas leaking is minimised by the use of special baffles (patents pending), and sometimes by the use of a patented gas "curtain." The steel pressings are not only kept bright and absolutely free from tarnish, but any rust on them, when put into the furnace, is reduced back to the metallic state, so that the pressings emerge with a much better surface than they had to start with.

The wire mesh belt furnace is in use for the annealing of steel of various kinds, copper, nickel, cupro-nickel, Monel, nickel-silver, standard silver and brass, in the form of flat sheets, coiled strip, coiled wire, blanks, pressings, etc., of all kinds. A large installation for annealing nickel and nickel alloy sheets is shown in Fig. 4.

The pusher type furnace has similar applications, but is somewhat less convenient to operate. It is chiefly used when the loads would be too heavy for the belt type,

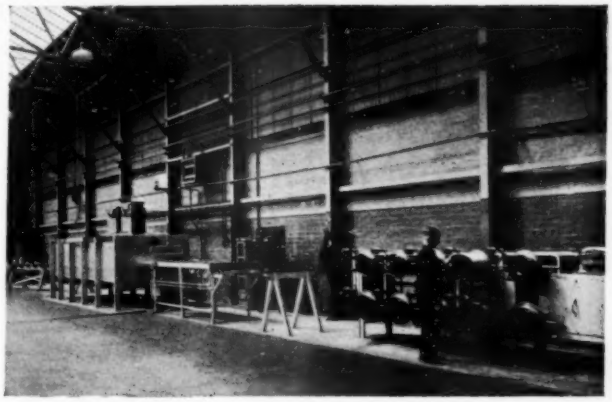


Fig. 7.—Continuous bright annealing of non-ferrous wire.

Roller-hearth Furnaces for Tubes and Rods.

The most suitable type of furnace for tubes in straight lengths is undoubtedly the roller hearth, as tubes readily lend themselves to conveyance by this means, and since only the material to be treated moves through the furnace no heat is wasted in heating belts or other carriers. The hearth consists of a series of externally-driven rollers suitably spaced, and provided with glands, so that the furnace is gas-tight. This last point constitutes one of the chief difficulties in using this method in a bright annealing furnace, but the difficulties have now been successfully overcome in practice.

Fig. 5 illustrates a furnace of this type being used for the bright annealing of non-ferrous tubes. A number of tubes can be seen entering the charging end of the furnace. This furnace has a rating of 100 k.w., and an overall length of 124 ft., with an effective track width of 2 ft. The tubes pass continuously from a loading space through the furnace, then through a long water-jacketed cooling chamber on to the unloading platform. To ensure maximum uniformity of treatment with a rapid input of heat to the tubes as they enter the furnace, it is divided into three separately controlled zones.

This type of furnace is more costly to build than the belt type, but is more efficient, and the life of the rollers very much greater than the life of a belt. The roller hearth furnace can be used for sheets, but the rollers must then be

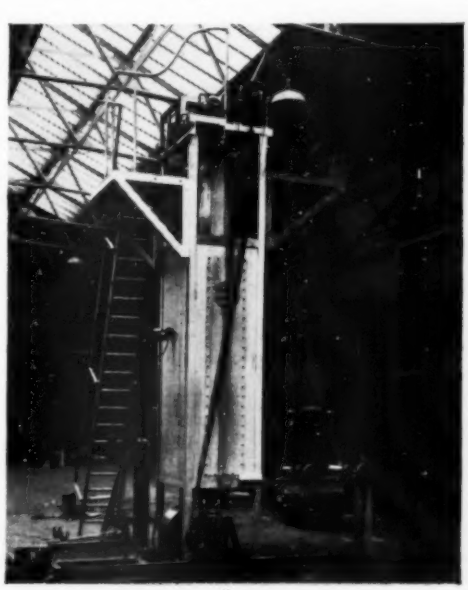


Fig. 8.—Continuous vertical furnace for continuous bright annealing of thin strip.

spaced more closely. Rollers are also often used in furnaces for annealing strip in single strands, in which case the rollers can be spaced widely, as the strip is under tension. In all roller hearth furnaces the surface speed of all the rollers must be exactly the same, and the rollers must be true and well finished—polished in some cases. With these precautions, marking and scratching may be entirely avoided with most metals, though without these precautions marking is inevitable.

Semi-continuous Type Furnaces.

Where the output is small or very varied the semi-continuous type is often useful. In this the charge, usually on a tray, is pushed into the heating chamber by hand and afterwards pushed through into a cooling chamber. Such a furnace, used for small parts, is shown in Fig. 6.

Continuous Single-strand Annealing.

Where the material is available in long lengths, single-strand annealing offers many advantages. The cost of

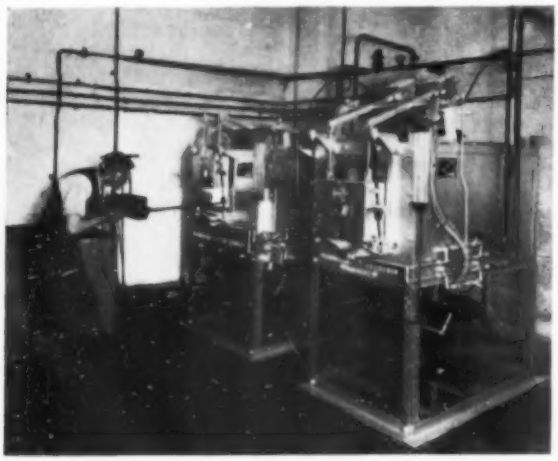


Fig. 9.—"Certain Curtain" furnaces for scale-free preheating and hardening of high-speed steel tools.

operation is usually greater than when annealing the same material in coiled form, but the better control of grain size and the perfect uniformity throughout the length, are features of great importance, which with some metals make this method a necessity.

The bright annealing of non-ferrous wires is commonly carried out in this way. Some of the nickel alloys (nickel-chromium) can only be bright annealed this way, and with others bulk annealing would produce excessive grain growth, and, moreover, the strands would be very liable to stick together. A furnace for continuously bright annealing wire is shown in Fig. 7.

Fig. 8 illustrates a vertical type of furnace annealing non-ferrous strip. This material is thin and highly polished, and it emerges from the furnace with the perfect mirror finish, if anything, somewhat improved. For heavier strip a horizontal type of furnace is used, this method being applied to steel and special alloy steels.

Special Gases for Bright Annealing.

Intimately connected with the design of suitable furnaces is the production of the protective gases used in them. Hydrogen and nitrogen have been used, purchased in a compressed form in cylinders, or in certain cases, produced on the site. Hydrogen is usually produced by electrolysis, and nitrogen by the fractional distillation of liquid air. The capital cost, however, of such plant is considerable, and the cost of compressed gases purchased commercially is prohibitive for all but a few special processes.

Cracked Ammonia.

A very convenient way of obtaining hydrogen and nitrogen is from anhydrous ammonia. With what is known as the ammonia cracker, the anhydrous ammonia may be broken up into its component gases, forming a mixture of 75% hydrogen and 25% nitrogen. This mixture is already dry, and may be used effectively as a substitute for hydrogen in practically all cases. The cost is less than half that of compressed hydrogen. A further development is the ammonia burner. In this apparatus anhydrous ammonia is partially cracked and burned with air. The resulting water vapour is condensed and the remaining gases consist of nitrogen with 1 to 10% of hydrogen, according to the relative proportion of ammonia and air.

Like cracked ammonia this mixture is non-toxic, but unlike it is non-explosive, and its cost is about half. These mixtures are completely free from impurities, and are excellent for most metals, being quite economical where some types of container are used. The higher consumption of gas, with large continuous furnaces with partially open ends, usually makes this source of protective atmosphere too expensive, and so a cheaper source has had to be sought.

Gases from Hydrocarbons.

One of the great difficulties is that most fuels from which protective atmospheres can be produced, such as coal gas, coke-oven gas, oil, etc., contain sulphur, which is injurious both to the metal to be treated and to the nickel-chromium heating elements and other parts of the furnace.

In America suitable gases can be produced by the treatment of natural gas, and also propane and butane, all of which are usually free from sulphur. Whilst in this country there is no suitable natural gas supply, butane can now be obtained. None of the fuel gases can be used in the raw state, largely because the hydrocarbons would break up or crack in the interior of the furnace, producing soot. Moreover, raw gas would be unnecessarily expensive. There have been many attempts and many methods evolved for cracking and partially burning the hydrocarbons, but it has often been found difficult both to obtain complete cracking and to ensure complete absence of oxygen in the resulting gas. Special apparatus, however, has now been evolved in which these objects are achieved. The composition of the resulting gas may be varied within certain limits by adjusting the ratio of raw fuel to air. For use with copper a highly reducing gas is neither necessary nor desirable, and almost complete combustion can be allowed to take place in the reaction chamber. Ferrous and many other metals require a more reducing gas, which is obtained by reducing the amount of air. Under these conditions the temperature in the reaction chamber will be lower, and difficulty may be experienced in ensuring complete cracking of the hydrocarbons, but this difficulty can be overcome by the special types of reaction chamber now designed. A very highly reducing gas, known as electrolene, which may contain as much as 75% hydrogen and 20% carbon monoxide, is produced by mixing the fuel gas with steam and passing it through an electrically-heated reaction chamber.

Attempts are being made to use cheaper fuels, such as coal gas and fuel oil, which contain sulphur. When almost complete combustion has taken place, most of the sulphur may be removed without great difficulty, but when a more highly reducing gas is required, the problem of sulphur removal becomes more difficult. It is, however, in sight of solution.

It is not proposed to deal with the production of protective atmospheres in greater detail now, but it will be seen that a number of suitable protective gases are available, the choice depending on the metal to be treated, the type of furnace, and local conditions.

Clean Hardening.

In the annealing processes which have been described, the material is cooled slowly, whereas in the hardening of steel the charge is rapidly cooled or quenched. Given a suitable gas, it is obvious that it will be possible to devise furnaces in which the steel, after being heated in a protective atmosphere, is quenched without coming in contact with air. Thus, furnaces such as the link-conveyer furnace, illustrated and described on page 118 (March, 1935) may be made gas-tight, and supplied with a suitable atmosphere. Such furnaces are in operation, giving a clean and satisfactorily hardened product. In the case of steel, however, it is not simply a question of preventing oxidation of the metal, or scaling, but of preventing the removal of carbon or decarburisation. Many gases which do not cause scale nevertheless rapidly decarburise steel. Carbon dioxide, water-vapour, and hydrogen, as well as oxygen, will decarburise steel. Carbon monoxide and hydrocarbons, such as methane, will carburise steel, and it is therefore necessary for the protective atmosphere to contain the various gases in such proportion that it is in equilibrium with the carbon in the steel. If these points are properly provided for, steel may be hardened completely free from scale or decarburisation.

It is especially important to be able to harden tool steel without scale or decarburisation, and this is especially the case with high-speed tool steel, which is hardened from a very high temperature up to nearly 1,400° C.

Small furnaces have been designed for the hardening both of high-speed tool steel and carbon steel tools, in which the furnace chamber is kept filled with a protective atmosphere. In one successful type the atmosphere is provided by the partial pre-combustion of coal gas and air, the partially combusted gas being then admitted into the furnace chamber. By regulating the proportions of air and gas the composition may be adjusted. In order to prevent the ingress of air when the door is opened, the gas and air supply is automatically increased and a gaseous screen is formed across the door opening, as the gases are admitted through a slot across the floor of the vestibule. These furnaces, known as " certain curtain " furnaces, are made with nickel-chromium elements for temperatures up to 1,000° C. for the treatment of carbon steels and for the pre-heating of high-speed tool steels, and with silicon-carbide elements, operating up to 1,400° C., for the hardening of high-speed tool steel.

A pair of these furnaces is shown in Fig. 9. The result of exact control of atmosphere as well as of temperature has a remarkable effect on the life of the tools, an increase in tool life of 100% over tools hardened in the ordinary way being common experience. This is obviously a matter of great importance where the tools have been expensive to manufacture.

A subject of growing importance is that of brazing in a protective atmosphere. The processes can be carried out in bright annealing furnaces, such as the belt-conveyer furnace. This subject is of growing importance, and warrants separate treatment so that it is not proposed to deal with it on this occasion.

Blending for Steam Generation

A MUCH neglected source of economy in steam boiler operation is blending of the coal, that is mixing two or more qualities of coal, or using other solid fuels when the local circumstances are favourable. Thus coke breeze from gas-works or coke-oven plants can often be obtained when the mill is situated in or near a large town.

A typical example of what can be accomplished is at a large colliery in South Wales, also operating extensive by-product coke-oven plant, and possessing a vast accumulation of coke breeze and dust, the result of many years' working. They desired particularly to burn wet slurry residue from the coal-washing plant, averaging 20 to 30% moisture after draining, and for this purpose the hand-fired " Lancashire " boilers were fitted with " Turbine " forced-draught furnaces equipped with fans and trunking in place of steam jets. This furnace will burn any material, from the highest to the lowest grade quality, including both washery slurry and coke breeze, but excellent results are being obtained by blending the coal washings 50 : 50 with the coke breeze, which burns much better under forced draught conditions than either of the two products separately, the wet coal having the beneficial effect of " binding " the dry friable coke breeze. Combustion also is absolutely smokeless, since the volatile content of the mixture is lower than 15%, while hand firing of the blend is easily carried out and the same applies to the cleaning, the ash being of a friable character almost like sand, with little or no clinker. On standard 30 ft. 0 in. × 8 ft. 0 in. " Lancashire " boilers also a high evaporation, up to 9,000 lbs. of water per boiler per hour, is being obtained.

The forced-draught furnace, a production of the Turbine Furnace Co., Ltd., as well known, consists essentially of a number of longitudinal, cast-iron trough firebars, about 6 in. wide, fixed side by side, in number according to the width of the grate required. Each of these contains a large number of small transverse bars or elements having inclined blades underneath like a turbine, which deflect the correct amount of air between the small transverse bars to the fire above, giving uniform and subdivided air distribution.

Forced draught is always used, given either by means of steam jets, which do not as a rule take more than 2 to

Typical installation of forced-draught furnaces with fans and trunking on a " Lancashire " boiler.

2½% of the evaporation of the boiler, or by mechanically driven fans with trunking. In this case the power is extremely small, usually less than 2 h.p. for a standard 30 ft. 0 in. × 8 ft. 0 in. " Lancashire " boiler. Further, the firing can be either by hand or by sprinkler stoker gear, that is of course, with a fixed grate and hand cleaning-out, while in addition there is provided when required an extension cleaning-out and secondary air admission grate at the back, which is useful for smoke prevention in the case of bituminous coal and also for assistance in cleaning out, part of the live fire being pushed back on to this extension to be used for igniting the fresh coal after the bulk of the ash and clinker has been removed.

Reviews of Current Literature.

Metallurgy

THIS is a new, revised, and enlarged edition of a well-known work which was first published in 1895. Several new editions have been published since that time and it has grown more comprehensive in consequence. In preparing this new edition Mr. Rhead has adhered to the sequence of former editions in order to develop the subject in a progressive manner and secure the primary object of the book—to inculcate and emphasise the importance of fundamental principles. Some deletion and condensation of matter has been done to keep the book within reasonable dimensions, and a considerable amount has been rewritten and rearranged. Large additions have been made in many sections in order to retain the comprehensive character of the original and to ensure that it will continue to be useful as an introduction of the subject to the practical man in industries dependent on metallic materials. New sections have been added on pyrometry, metallography, and foundry work containing sufficient fundamental work to serve as a basis for further study while illustrating the matters dealt with. Notable additions have been made in the sections dealing with physical tests, fuel, especially modern coking plant, electric furnaces for steel manufacture and other melting and smelting processes, also much matter dealing with developments in wet and dry processes for both base and precious metals has been added.

The fact that this is the fifth edition including new impressions is sufficient evidence that this book supplies a special need. The author covers an immense field, yet the matter is presented in such a lucid and concise manner that the book remains one of convenient size. It is well illustrated and excellently produced, and remains one of the best elementary text-books on metallurgy available. While students will find it valuable it should be especially valuable to the practical man who requires fundamental information on metals and processes associated with their production.

By E. L. RHEAD, M.Sc.Tech., F.I.C., A.I.M.E. Published by Longmans, Green and Co., Ltd., 39, Paternoster Row, London, E.C. 4. Price 10s. 6d. net.

The Working, Heat-treating and Welding of Steel

IN this book an effort has been made to present in as concise a way as possible the practice associated with working, heat-treating, and welding of steel, but however much it may be desired to adhere to practice in dealing with steel, some knowledge of its chemical composition and physical constitution is essential, as well as other subjects incidental to a proper appreciation of the working and heat-treatment of steel, such as physical testing. To cover the subjects discussed in about 180 pages is very difficult, and as can be appreciated, the author has been concerned primarily with the principles involved. It is planned as a text-book, as will be noted in the arrangement of the matter, which commences with information on the development of iron and steel products, and follows on with the chemical composition of steel, its classification, physical testing, the effects of temperature changes, and mechanical working, plant and processes for its working, its physical constitution, heat-treatment process and equipment, a discussion on alloy steels and their heat-treatments, process and equipment for welding steel, and the preservation of steel.

As an introductory to the study of certain prescribed phases of the metallurgy of steel, the book is valuable, and will be appreciated by students of metallurgy and those who have already entered the various sections of industry embraced by the title. An interesting addition at the end of each chapter is a series of questions, a consideration of which will undoubtedly assist students to a better understanding of the various phases. Some of the grain size diagrams associated with the effects of temperature changes, are very effective and could be used with advantage by instructors and teachers. Another useful addition is a series of eighteen laboratory assignments which gives a very useful course of work on forging, hardening, tempering, and welding and, wherever possible, charts, diagrams, section drawings, and micrographs are provided to facilitate a proper understanding of the subjects discussed in the text.

By HARRY L. CAMPBELL, M.S. Published by Messrs. Chapman and Hall, Ltd., Henrietta Street, Covent Garden, London, W.C. 2. Price 11s. 6d. net.

A German-English Dictionary for Chemists

To the advanced worker in chemistry a knowledge of German is almost indispensable, since a large proportion of chemical literature is published in that language. Even if he has had a good general course in German, he must become familiar with an immense special vocabulary which no dictionary can give completely. This dictionary, however, is not solely confined to chemical terms, it includes words from related fields of science and also a general vocabulary. This latter, which is superior to the average pocket dictionary, has been included to save the user the trouble of looking up the more common German words in a separate dictionary, and also because many general words have one or more technical meanings. In a general work these meanings are often either absent or buried among other senses. In this dictionary the special chemical meaning is put first or indicated in some way, the aim being to give the user immediately the meaning he is most likely to be seeking.

The difficulty of mastering two languages with that degree of perfection which dictionary-making requires is best appreciated by those who have endeavoured to grasp a foreign speech in its native home; this is particularly true when translating the proper meaning of technical language In this dictionary the compiler has produced a very useful and comprehensive book, which cannot fail to help the translator to a clearer understanding of the matter which he is translating. This publication is the second edition, and the vocabulary has grown to about 42,000 entries. It is a handy and convenient size, and is an ideal work of reference to all who are intimately concerned with the chemical industries.

By AUSTIN M. PATTERSON, Ph.D. Published by Messrs. Chapman and Hall, Ltd., Henrietta Street, Covent Gardens, London, W.C. 2. Price 15s. net.

Microstructure of Al and its Alloys.—H. Nishimura, "Kinzoku" (The J. of Metals), 4, 179-84, 321-6 (1934). Microstructures of Al-Cu, Al-Si, Al-Mg, Al-Zn-Cu, and Al-Si-Cu alloys were investigated. A new equilibrium diagram of Al-Cu alloy was shown by author's laboratory. In Lautal and other Al-Cu-Si alloys, Al dendrite of primary crystal is formed with $CuAl_2$ surrounding Al, and ternary eutectic of these two and Si is found.

Growth of Cast Iron by Heating at Elevated Temperature.—T. Kikuta, "Kinzoku" (The J. of Metals), 4, 219-23, 299-305, 327-32, 369-74, 403-8 (1934). A complete investigation of growth of cast iron by heating at elevated temperature is shown in this paper. Specific weight of grey cast iron on various heat-treatments, thermal expansion of grey and white cast iron, effects of various elements for growth of cast iron, and theories about the growth of cast iron are stated. The growth of cast iron occurs owing to irregular expansion at A_1 transformation point, with consideration of graphite flake in matrix, diffusion of carbon from spherical graphite, and expansion by graphitisation at Ar_1 point.

Alloy Cast Irons

By J. E. HURST.

During recent years the addition of alloys to cast iron has become the basis of developments in cast-iron metallurgy which have firmly established themselves as possessing clearly defined economic advantages. To-day alloy cast irons of high strength properties, capable of being heat-treated by hardening and tempering and nitrogen hardening processes, martensitic cast irons and austenitic cast irons are being increasingly used in widely varying applications.

FOR many years the addition of various alloying elements to cast iron has aroused the interest of investigators. It is probable that this interest is in the main inspired by the marked changes in properties and outstanding advantages of considerable commercial value which have arisen from the use of similar additions to steels. In spite of persistent efforts, with one or two exceptions very little headway in the application of alloy additions to cast iron has been made until recent years. Two notable exceptions are the high silicon acid-resisting cast iron and the nickel manganese austenitic cast iron known as No-Mag. The former is a cast iron containing from 12 to 16% silicon. It appears to have been first introduced in France about the year 1900 by Adolphe Jouve, and has been manufactured continuously over this period. No-Mag was introduced by Mr. S. E. Dawson (British Patent No. 204508), and contains sufficient nickel and manganese to render the material austenitic and consequently non-magnetic. A typical analysis shows 10% nickel and 5% manganese, and as such very probably marks the earliest commercial development of the austenitic cast irons. Apart from these, the only progress made up to a few years ago appears to have consisted of the intentional addition of small quantities of such elements as copper, nickel, aluminium and chromium to cast iron on the part of a few individual foundries, and there is evidence that, from time to time, attempts were made to develop alloy cast irons of notable alloy content having distinctive properties for certain specific purposes. For example, the author has a record of the examination of special hard cast iron limit gauges supplied by a firm (Tylor and Sons, Ltd.) in January, 1919. The chemical analysis of one of these specimens was as follows :—

	%		%
C.C.	0·48	Mn	0·57
Gr	2·22	S	0·08
Tot. C	2·70	P	0·94
Si	1·48	Ni	8·23

Surely this must be regarded as a very early example of the use of nickel additions to cast iron for the production of the now familiar hard martensitic cast irons. Another example which occurred again during the war period was the use of additions of tin to cast iron. The use of tin additions to cast iron for the production of press tools, particularly for shell-piercing, was investigated and developed by Guillet in France, and is fully described in a special volume published by *Revue de Metallurgie* in 1917, entitled " Researches on Shell Manufacture." Incidentally, it was shown that additions of this element considerably increased the hardness of cast iron, due to the formation of a compound of tin and iron. It was concluded also that in quantities up to 5% tin was a desirable addition to castings which are required to maintain a considerable degree of hardness at high temperatures.

The position as regards the addition of alloying elements around the years 1926 to 1928 cannot be illustrated better than by the following quotation from Dr. Hatfield (" Cast Iron in the Light of Recent Research," 3rd edition, 1928), in which he opens the chapter dealing with the influence of special elements in the following words : " It cannot be said, as in the case of steel, that the special elements are alloyed with cast iron with great advantage." The author himself, in his own book, published two years earlier (" Metallurgy of Cast Iron," 1st edition, 1926) expressed a similar view in the words : " Generally speaking, the high costs of the special elements, coupled with the difficulty of melting, casting, and manipulating the resulting alloys, are of sufficient magnitude to outweigh the advantages in mechanical and physical properties obtained." It is only fair to add that in both cases the view was held that future research might modify this position, and Dr. Hatfield stated definitely that " future research may modify this view, particularly as regards some of the special characteristics and also as regards resistance to temperature effects." These references serve an additional purpose in emphasising the short period of years during which the addition of alloys to cast iron has become the basis of developments in cast-iron metallurgy which have firmly established themselves as possessing clearly defined economic advantages. To-day, alloy cast irons of high strength properties, capable of being heat-treated by hardening and tempering and nitrogen hardening processes, martensitic cast irons and austenitic cast irons are being freely used.

High-duty Alloy Cast Irons.

(*a*) *Nickel and Nickel Alloy Cast Irons.*—It is true undoubtedly that the most popular of the high-duty alloy cast irons to-day are those containing nickel, either alone or in conjunction with other elements, particularly chromium. So much has been written and said on the subject of nickel additions to cast iron that it is superfluous to attempt to do more than briefly summarise their effect. The addition of nickel eliminates chill and hard spots, and as a result ensures improved and more regular machining properties—a matter of great industrial importance in mass production castings. It is also claimed for nickel additions that they equalise the structure in thin and thick sections, thus eliminating the different structures normally developed on account of the different cooling rates of the various parts. The grain of the metal is simultaneously refined, thereby giving higher strength and pressure tightness. In general, the desired results are obtained in engineering irons by the addition of 1·0 to 1·5% nickel, accompanied by a reduction in the silicon content of about 0·5%. As an alternative to the reduction in the silicon content, the use of a combined nickel and chromium content is recommended, the chromium serving to harden the iron just as in the case of the silicon reduction. The nickel-chromium additions are generally made in the ratio of three parts of nickel to each part of chromium. A common specification is 1·5% nickel, 0·5% chromium. The combined nickel-chromium addition is recommended as being very satisfactory, where improved strength, wearing quality, or heat resistance is required, but where improved pressure tightness combined with free machining qualities is of importance, the combination of nickel with low silicon is to be preferred.

The most recent development in the production of nickel cast irons is of still greater intrinsic importance. This development is covered by the British Patent Nos. 290267 and 352510, and relates to the use of nickel for the production of nickel alloy cast irons possessing tensile strengths up to 30 tons per sq. in. A fuller description of the pro-

cesses of producing these alloys is given in the publication B 15 of the Bureau of Information on Nickel, and consists essentially in the preparation of cast-iron alloy of a composition which normally would cast white. When graphitisation of such a cast iron is brought about by the addition of suitable proportions of nickel and silicon a grey alloy cast-iron product results which has repeatedly given the remarkably high strength values of 30 tons per sq. in., and uniformity of structure over widely varying sections. It is apparent that for the best results it is of considerable importance to control the total carbon contents, but the diagram (Fig. 1) gives some idea of the strength ranges which can be attained in this type of iron. The facility of production of high strength cast iron of this order is surely an outstanding advantage of the addition of the non-ferrous metal nickel.

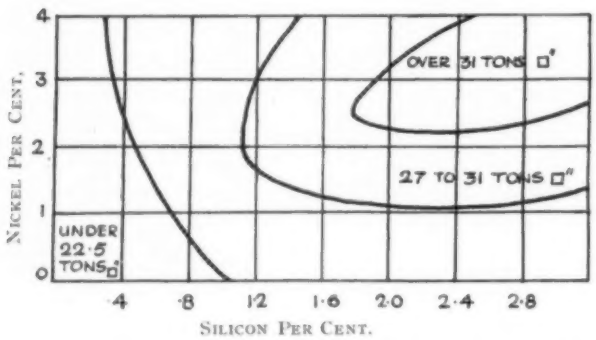


Fig. 1.—Diagram showing strengths obtainable in high strength cast iron with various percentages of nickel and silicon.

(*b*) *Chromium and Chromium Alloy Cast Irons.*—The use of chromium additions in conjunction with nickel in the production of high strength alloy cast iron has already been referred to. This element is used alone in quantities of 0·25 to 0·75% in grey irons, particularly for automobile cylinder castings. Broadly, the effect of chromium is to stabilise the combined carbon content, and this addition of chromium to grey cylinder irons is accompanied by the maintenance of a higher hardness level and cylinder blocks, liners and piston rings have been found to have an improved life in service over non-chromium alloy material.

Chromium alloy additions are used in the production of castings intended for heat-resistance purposes, as, for example, fire-bars and castings for furnace parts. The addition of chromium in quantities of from 0·25 to 1·0% to a white base iron has found extensive application for those castings required for heat-resisting purposes, on which no machining is required. Typical examples of compositions of alloy cast irons of this type which have come to the author's notice are given in the following table :—

Spec. No.	Tot. C, %.	Gr, %.	Si, %.	Mn, %.	S, %.	P, %.	Cr, %.	Purpose.
1	3·21	Nil	0·98	0·38	0·11	0·54	0·43	Firebar
2	3·49	Nil	0·75	0·54	0·10	0·11	0·75	Furnace door frame.

The addition of chromium has been resorted to in the production of cast-iron rolls. A typical range of compositions for this purpose is that disclosed in U.S.A. Patent No. 1,702,128, by the Mesta Machine Co., as follows :—

Tot. C	2·0 to 4·0%	S	Less than 0·2%
Si	0·5 to 2·0%	P	Less than 0·3%
Mn	0·1 to 1·5%	Cr	1·8 to 4·0%

The use of very high chromium contents for cast-iron rolls has been adopted to a limited extent, and is said to have given satisfactory results. The amount of chromium in this case was 15%, and the full composition recorded is given below :—

	%		%
Tot. C.	3·5	P	0·03
Si	0·7—1·0	Cr	15·0
Mn	0·3	Ni	0·5
S	0·04		

(*d*) *Molybdenum Cast Irons.*—The element molybdenum has attained a position of considerable importance in ferrous metallurgy, and interest in the effect of its addition to cast-iron alloys has been very great. The addition of small percentages of molybdenum does undoubtedly lead to increased tensile strength. Whilst this property is of value in certain directions, the use of molybdenum depends upon its ability to reduce the effect of mass, or, in other words, to produce greater uniformity in properties throughout a given section.

Considerable attention has been given to the addition of this element to cast-iron roll mixtures, particularly in America. It is claimed for such rolls that they are stronger, there is less breakage in service, greater resistance to wear, less frequent dressing, and a smoother and better finish to the rolled products. Several roll manufacturers in this country have, during recent years, introduced molybdenum into their mixtures. A typical composition of a molybdenum cast iron chilled roll is given as follows :—

	%		%
Tot. C	2·96	S	0·06
Si	0·60	P	0·34
Mn	0·27	Mo	0·28

The joint additions of chromium and molybdenum to roll metal have been made the subject of a recent British patent application. The preferred composition is given as follows :—

	%		%
Tot. C	3·00—3·75	P	Under 0·10
Si	over 0·75	Cr	0·90—1·25
Mn	0·20—0·80	Mo	0·15—0·80

Exceptionally high additions of chromium and molybdenum have been recorded for cast-iron rolls. Such a composition is given below :—

	%		%
Tot. C	1·4	P	0·03
Si	0·7—1·0	Cr	2·00
Mn	0·30	Mo	1·00
S	0·04		

The joint addition of nickel and molybdenum and also chromium and molybdenum, is resorted to in special cases. Piwowarsky, in his investigations, considers that a combination of vanadium with tungsten or molybdenum as giving an alloy cast iron not without promise. Molybdenum cast irons can be made having air-hardening properties, and additions of molybdenum are being made for this purpose.

A malleable cast iron under the name "Moly Iron" is recorded as being used in America for the manufacture of brake drums. This material contains 2% carbon and 1·75% silicon, and is subjected to an 8-hour anneal. To obtain higher Brinell hardness, 0·25% molybdenum is added to the base mixture. Another variation of this is the addition of suitable amounts of copper and manganese to the base mixture.

Alloy Cast Irons for Hardening and Tempering.

A most important development in the application of additions to cast iron is in the production of alloy cast irons suitable for hardening by processes of hardening and tempering exactly as in the case of steels. As is well known, there are many engineering applications where materials are required in the hard condition, and until the discovery of the facility of hardening and tempering cast iron it was only possible to produce such parts in cast iron, initially hard, in the "as cast" condition. The facility for hardening and tempering cast iron is obviously invaluable, as it permits preliminary machining operations of an involved

and intricate character being carried out on the material in the soft condition "as cast" and hardening can be carried out subsequently by the heat-treatment operations of quenching and tempering. This development is due primarily to modern research work, wherein it has been shown very clearly that throughout such heat-treatment neither the strength properties nor brittleness of the cast iron is impaired, but in the case of suitable compositions, and with suitable treatments, the strength properties are actually improved.

This is illustrated by the diagram (Fig. 2), which is typical of the changes in hardness obtained by suitable hardening and tempering treatment. In the oil-quenched condition the hardness is raised to approximately 500 Brinell, and the ultimate strength lowered considerably. In this condition the material is weak and fragile, and it is only after subsequent tempering that the strength of the material is restored. In this particular instance, at a temperature of tempering of 450° C. the ultimate strength is raised to a value substantially in excess of that of the material in its original "as cast" condition. With this treatment, the hardness is lowered slightly with increasing tempering temperatures. As in the case of steels, the material in the quenched condition shows a strongly martensitic structure, as shown in the photo-micrographs. Tempering is, of course, accompanied by a gradual decomposition of the martensite in the usual manner.

In suitable thin sections, most plain unalloyed cast iron is capable of being hardened by oil quenching from suitable temperatures. In a like manner, plain chromium, copper, aluminium-chromium, molybdenum and vanadium with or without chromium, when alloyed with cast iron have the effect of improving the hardening properties, and the presence of nickel is not a *sine qua non* in alloy cast irons for hardening purposes. Nickel is, however, a useful constituent in such irons in that it lowers the critical speed of quenching, and has a very marked effect in increasing the depth of penetration of the hardening effect in thicker sections of material. The effect of thickness of section is of great importance, and must be taken into consideration in fixing the most suitable alloy composition for a given type of casting intended for hardening purposes.

The effect of nickel in increasing the critical speed of quenching is of importance in relation to considerations of thickness, and it will be appreciated that in certain circumstances it is possible to have too much nickel present, when quenching will tend towards the retention of the austenitic condition with a consequent lack of hardening effect. With sufficient nickel present, the alloy cast iron can be allowed to cool down in air to obtain the air-hardening effect. Such air-hardening alloy cast irons are produced commercially, and a typical range of compositions are described in British Patent No. 342335, Picken.

	%		%
Tot. C	2·70—3·50	Mn	0·50—1·50
Si	1·00—3·00	Ni	3·00—6·00
S	0·14 max.	Cr.....	1·50—2·00
P.....	1·00 „		

Alloy Cast Irons Suitable for Nitrogen Hardening.

As indicated already, the alloy cast irons developed for nitrogen hardening purposes contain essentially the non-ferrous elements aluminium and chromium. Typical compositions and properties have been described by the writer (*J.I.S.I.*, No. 1, 1932), and an example is given below :—

	%		%
Tot. C	2·65	P	0·096
Si	2·58	Al.....	1·43
Mn	0·61	Cr.....	1·69

Castings in this alloy can be surface hardened by treating in anhydrous ammonia gas at a temperature of 500° C. The surface hardness developed by this treatment is from 900 to 1,100 measured by the Firth diamond hardness tester, and the depth of penetration with a treatment of 80 hours is from 0·015 in. to 0·030 in.

Alloy cast irons of this type in the nitrogen-hardened condition are being used extensively for cylinder liners, and are produced and sold in th s country by the firm with which the author is connected under the trade mark "Centrard." Other general castings are being produced also, and the super-hard surfaces are found to have numerous applications under conditions where resistance to wear is required.

Martensitic Cast Irons.

The addition of increasing amounts of nickel to cast iron is accompanied by an increase in hardness and in ordinary commercial sections of from ¼ in. to 1 in. thickness, the maximum hardness is obtained with nickel additions of between 5 and 6%. The structure of such nickel-hardened cast irons is martensitic, and hence the use of the phrase

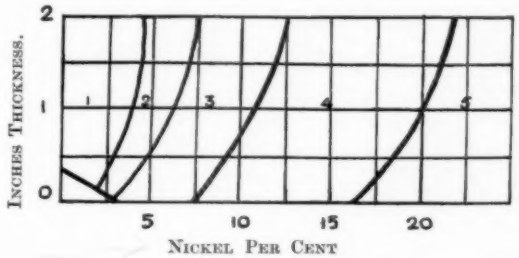


Fig. 2.—The effect of hardening and tempering on the properties of cast iron.

"martensitic cast irons" in their description. The diagram (Fig. 3) illustrates the approximate influence of nickel additions on the structural characteristics of cast iron of average composition. The hardness of such martensitic cast irons is in the neighbourhood of 400, and whilst this is not so easily machined as ordinary cast iron, modern machine tools and cutting tools are able to machine such irons economically. The joint addition of nickel with chromium can be used for the production of such castings, and in this case the amount of nickel can be lowered.

The use of alloy additions to white irons or chilled irons has been referred to on several occasions, particularly in reference to the use of alloys in the production of rolls.

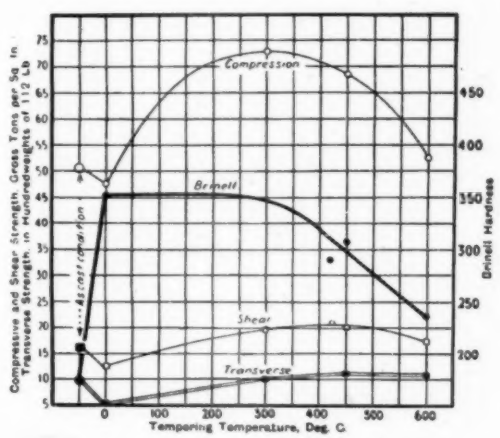


Fig. 3.—Influence of nickel on structural character of cast iron.

The hardness and also the strength properties of white irons can be increased by alloy additions, and many such are used for this purpose. The joint addition of nickel and chromium, or molybdenum and chromium, for this purpose are the most usual methods adopted, and in many of these cases the strength properties are increased by as much as 100%, in addition to a substantial increase in the intrinsic hardness. The development of these alloys has already resulted in the production of materials which are likely to prove formidable rivals to many of the special steels hitherto used for this purpose.

Austenitic Cast Irons.

A number of elements and combinations of elements when added to iron carbon alloys have the effect of preserving the austenitic condition at normal temperatures. Two examples of the commoner elements which have this effect are nickel and manganese. The diagram (Fig. 3) may be used to illustrate the effect of simple additions of nickel to a normal cast iron from which it will be observed that with simple additions of nickel of over 15% the structural condition of the cast iron at normal temperatures assumes the austenitic character. The structural character of typical austenitic cast irons is illustrated in the photomicrograph (Fig. 4). The main mass of the structure is the white uniformly etched constituent austenite. As in the

Fig. 4.—Austenitic cast iron, etched. × 200 diams.

case of ordinary cast irons, the austenite is accompanied by the presence of graphite and possibly carbides. The presence of increasing amounts of carbides is visible in the three structures shown. In commercial austenitic cast irons the phosphorus constituents may be present also, depending upon the actual composition of the material, and naturally the properties are modified somewhat by the presence of these extraneous constituents and substantial variations in the properties can be provided for by modification in the chemical composition.

Three of the most important of the commercial austenitic cast irons are known as No-Mag, Ni-Resist, and Nicrosilal. The essential feature of No-Mag is the presence of nickel and manganese. A typical composition contains 10% nickel and 5% manganese. Some nickel may be replaced by copper, and the presence of aluminium is recommended also. A composition containing copper is as follows: Nickel, 5%; copper, 5%; manganese, 5%; and aluminium, 1%.

Ni-Resist is a nickel-copper-chromium austenitic cast iron, and is manufactured commercially with slight variations in composition under a variety of names, such as Nimol, Hypocrode, No. 7 alloy, etc. Typical compositions of these alloy cast irons lie within the following limits:—

	%		%
Tot. C	2·8 —3·1	Ni	12·5—14·5
Si	1·3 —1·7	Cu	5—7
Mn	0·75—1·25	Cr.....	2·5—6
P.....	0·10—0·5		

Nicrosilal is a recent development in this field, and is a nickel-silicon-chromium cast iron, the invention of the British Cast Iron Research Association (British Patent No. 378508). The composition of Nicrosilal is approximately as follows:—

	%		%
Tot. C	1·75	Cr.....	1·5—5
Si	5—6	Mn	up to 1·0
Ni	18·0		

The general properties of the austenitic cast irons are quite distinctive. The true austenitic cast irons are generally non-magnetic or feebly magnetic of medium strength and Brinell hardness. They generally possess a low elastic limit and high deformability. They are susceptible to work hardening and do not harden on quenching. Certain composition can be temper-hardened or are susceptible to precipitation hardening. Another feature of great importance in these alloys is their high coefficient of expansion and their low thermal conductivity. The following table summarises the approximate values of the principal general properties of austenitic cast irons in comparison with those of ordinary cast iron and the common non-ferrous alloys, brass and bronze. The comparison with brass and bronze has been drawn deliberately with a view to emphasising a very important aspect of these new cast-iron alloys. In many respects they closely resemble these common non-ferrous alloys. For example, some of the austenitic cast irons have remarkable resistance to corrosion, and their behaviour in this respect very closely resembles that of the bronzes.

This resemblance has led to a study of the commercial application of austenitic cast irons to the production of decorative metal castings. There are those who believe that the public taste in colour of decorative metal work is undergoing a change away from the yellow metals in the direction of the more steely colours, and if this is the case it is possible that, through these newly discovered austenitic cast irons, the ironfoundry may regain the important position it used to possess in the supply of decorative metal fittings.

The potential decorative value of the austenitic cast irons is by no means the most important, as these alloys find extensive use already in the electrical trades on account of their non-magnetic and high resistivity properties. The corrosion-resisting properties render these alloys of great value in many sections of the engineering and chemical industries. Another outstanding application lies in their use for parts called upon to resist erosion and suitable compositions of austenitic cast irons have met with considerable success in the production of pump castings for this purpose. The austenitic cast irons show marked superiority over ordinary cast iron at elevated temperatures, and have a high resistance to scaling and growth. Nicrosilal was developed originally for heat-resisting purposes, and already has found numerous applications.

GENERAL PROPERTIES OF AUSTENITIC CAST IRONS COMPARED WITH CAST IRON AND NON-FERROUS ALLOYS.

—	Austenitic Cast Iron.	Ordinary Cast Iron.	Brass.	Bronze.
Specific gravity	7·5—7·6	6·9—7·7	8·0—8·2	8·2—8·5
Specific heat, 0° to 100° C.	—	0·12	0·09	—
Thermal conductivity	0·08	0·11—0·13	0·26	0·26
Magnetic permeability maximum	1·03	240	1·0	1·0
Specific resistance, microhms per Cm^3	150	95	7·0	16·0
Resistance temp. coeffic., 0° to 100° C...	0·00045	0·0019	0·002	0·00065
Coefficient of expansion	$1·8\times10^5$	$1·1\times10^5$	$1·88—1·98\times10^5$	$1·8\times10^5$
Tensile strength	15—25	12—20	20—40	20 tons in.[2] approx.
Elongation	1—3%	Nil	20%	8%
Mod. of elasticity, lb. in.$^2\times10^6$.....	14—21	14—18	11—14	11—14

High-tin Bronze.—C. H. Tonamy, "Kinzoku" (The J. of Metals), 4, 401-2 (1934). Even in heat-treated gunmetal the obtainable tensile strength is about 20 tons per sq. in. Therefore, when higher strength Cu alloy is wanted, heat-treated high-tin bronze is recommended in place of manganese bronze or aluminium bronze. As three specimens containing 20, 22, and 24% of Sn respectively are held at 650° C. for 1½ hour and then quenched in water, they show respectively 26·21, 26·80, and 25·00 tons per sq. in. of tensile strength, and 12·5, 3·0, and 2·0% of elongation respectively.

Manganese steel, because of its ability to withstand shock, is claimed to be the safest for crusher segments employed at by-product coke plants for crushing the coal. Surfacing the tips of these segments with a hard-facing alloy improves their life.

THE BRITISH INDUSTRIES FAIR

This national effort to display the resources of British industry is of an outstanding character. It is staged at a time when there is evidence of recovery, and the indications are that it will surpass any former exhibition held at Castle Bromwich. In this article some of the exhibits will be described and emphasis laid on the fact that the exhibits reflect the ceaseless endeavour to improve products by the development of improved plant and equipment and of the technique employed in manufacture.

IN addition to staging the British Industries Fair in three sections, this is the first year since its inauguration that one of the sections has been held at a different time. Organised by the Department of Overseas Trade with the object of bringing together potential buyers and manufacturers with a view to promoting sales, it was considered by many exhibitors of the heavy section that February was too early in the year to be as effective as it might be, thus it was decided, after much consultation, to delay the exhibition of this section until this month. That this change has met with general approval is indicated by the fact that not only has a greater area been taken to house the exhibits, but the number of exhibitors is greatly in excess of former years. It is true that the desire for more accommodation may be due to improved trade, but apart from this fact, the value of the exhibition is being increasingly appreciated, so much so that a growing number of exhibitors feel they must be represented.

Some manufacturers, on the other hand, continue to regard the Fair as an expensive luxury, and suggest that it would be more profitable to direct the same energy on plant reconstruction and other developments instead of using it on display. Whilst it is necessary that there should be gradual improvement in the quality of a product, the quantity produced in a given time, more economical production, or a combination of these improvements, for which modern plant and equipment and improved technique may be required, it is just as necessary to display the products to facilitate sales. We are all familiar with what was once the proud boast of Great Britain—that she was the workshop of the world. But many other countries have since become industrialised to a very high degree, while the number and variety of products are so diversified that an exhibition such as that staged at Castle Bromwich is not only a national shop window, dressed to illustrate this variety, but is an education to even the casual visitor.

Although primarily held with a view to developing business, this annual exhibition demonstrates the progress of the science and arts in the service of mankind, particularly the extent to which the British people are contributing. A year, of course, is a comparatively short time to show definite progress; making comparisons over a period of years the extent of the progress is at once apparent, but actually developments are continually being made, and in comparison with last year's effort, the discerning visitor will note the progressive tendency.

At the Castle Bromwich exhibition, which will remain open until May 31, the exhibits come within the following trade schedule: Hardware, ironmongery, brassfoundry, farm and garden equipment, general building, heating and cooking, electricity (industrial and domestic), light and heavy engineering, metals, road construction plant and materials. The absurdity of attempting to review such a comprehensive range in this article will be appreciated. It is, however, proposed to refer to some of the outstanding exhibits that have a direct bearing upon ferrous or non-ferrous metal production, in semi-finished and finished forms, together with the developments and products of those industries closely associated as users of these materials. Various forms of plant and equipment in which developments have been incorporated, will also be discussed, and an effort made to direct the visitor, with limited time at his disposal, to those exhibits which have outstanding qualities. Every effort has been made to ensure the accuracy of the information. In many instances important and interesting exhibits are omitted because adequate information is not available at the time of going to press.

Considerable strides have been made in the facility with which special alloys are manipulated. This illustration shows a group of "Staybrite" steel pressings.

Metallurgical Progress.

Few new alloys will be on view. Attention during the year has been directed to improving existing alloys, particularly with a view to meeting the requirements of increased stresses, resulting from high speeds of transport. This is especially true in the aeronautical, automobile, and marine engineering fields; increased pressure and temperatures in various types of steam plant have also involved much research work, and considerable progress has been effected; in the chemical industry the demand for corrosion and heat-resisting materials of an exceptional character is being supplied more effectively than a year ago. It can be said with confidence that in both the ferrous and non-ferrous metals industries improvements have resulted in products of higher quality.

In addition to research work, there has been commend-

able developments on the production side. The iron and steel industry, for instance, has carried out considerable modifications to existing or installed new plant and equipment. Blast-furnaces have been modernised or renewed, new steel furnaces installed and rolling mills modified or entirely renewed, with the result that considerable progress

Group of Pelton wheel buckets in Firth-Vickers stainless steel

has been effected in the speed of production in addition to quality. One outstanding result of reconstruction of this character is the " Diamet " steels of Samuel Fox and Co., Ltd., one of the firms incorporated in the United Steel Companies, Ltd.

During the past twelve months this firm has put into operation the largest high-frequency electric steel-melting plant in Great Britain. This plant has a furnace capacity of 2 tons and 5 tons, and because of the method of manufacture, the steels produced are remarkably free from non-metallic inclusions. They undergo a special system of disc-inspection and metallurgical examination and testing to ensure that they are as perfect steels as can be manufactured by present-known methods. The steels have been given the trade name of " Diamet," and a pictorial display of the methods of manufacture, with examples of the uses of " Diamet " steels is shown on the stand (D 506).

Carbon and Alloy Steels.

For the first time, Firth-Vickers Stainless Steels, Ltd., will be showing at the British Industries Fair, though, of course, under this name there are fused the Stainless and Staybrite steel-making interests of Messrs. Thos. Firth and John Brown, Ltd., and the English Steel Corporation, Ltd. The Staybrite steel stand is well known, even to the casual visitor, because it has always been a prominent feature at Castle Bromwich. On this occasion it will again demonstrate the remarkable strides which have been made in the technique of producing all classes of acid and rust-resisting plant and the vast range of domestic applications from the world-famous " Staybrite " steel now made exclusively, of course, by the company. Considerable attention is also given to the latest developments in heat-resisting steels.

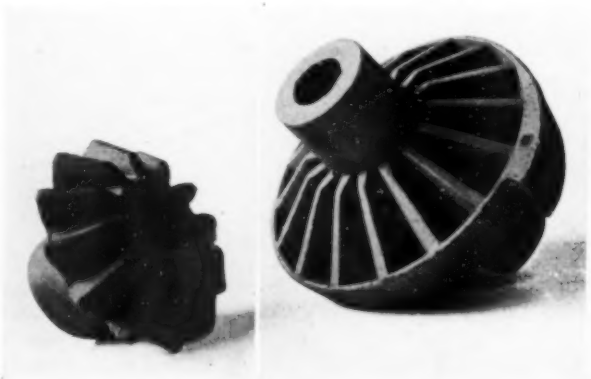
As is well known, the response of a metal to corroding influences is determined by its composition and structural condition and the composition, concentration, temperature, and physical condition of the corroding media. These constitute such a complex set of variables that, for practical purposes, the common-sense method of determining the suitability of a particular alloy is a test-out under working conditions, and the Firth-Vickers Company welcome this method of satisfying requirements. Initially, stainless steels consisted of plain 12 to 14 % chromium steels, and while these fulfil many useful purposes, subsequent research showed that steels containing higher percentages of chromium, together with considerable quantities of nickel, exhibited superior corrosion resistance, at the same time giving increased ease of manipulation and fabrication. This led to the 18/8 austenitic chromium-nickel, which, with a low carbon content, has an optimum resistance to a wide range of corroding media.

Among many brands of stainless steels are the " Silver Fox " types manufactured in the new high-frequency melting plant at the works of Samuel Fox and Co., Ltd. These are achieving remarkable success because of their ductility and ease of polishing. The exhibits include examples of the application of these steels, including a welded lining in " Silver Fox 22 " quality. Because of its low carbon content, this quality is claimed to be free from weld-decay. A connecting rod, manufactured in " Tormol " steel—one of the alloy steels made by this firm—and forged by Daniel Doncaster and Sons, Ltd., is also being exhibited, together with slide bars and piston-rod forgings. " Tormol " steel is used largely for railway purposes. It has an advantage over carbon steel in that it is lighter in weight for a given strength, and so enables considerable saving in the weight of reciprocating parts to be made.

Two years ago the United Steel Companies, Ltd., through their branches, Steel, Peech and Tozer and United Strip and Bar Mills introduced " Phœnix " (standardised) rapid machining steel, which, it is claimed, supersedes ordinary free-cutting steels. Tests show that this steel can be machined at speeds much higher than even present-day demands, and that it can also be used for parts carrying stress and subject to shock. It has a very wide and varied application, a selection of which is shown.

Attention should be directed to the exhibits of British Rolling Mill, Ltd., whose " Brymill " tested steels include various qualities of case-hardening, oil-hardening, deep-drawing and straight carbon steels. Every steel and every process in manufacture is controlled by careful laboratory checking and a high level of quality, and consistency is aimed at. The steels are available in various finishes, including bright turned, bright drawn, bright cold-rolled, hot-rolled, and in the heat-treated condition. In addition to exhibits of these steels, a full range of stampings, pressings, machined parts, etc., will illustrate the various possibilities of the different qualities.

A variety of pressings are exhibited by J. B. and S. Lees, Ltd., made from various qualities of hot-rolled and cold-rolled strip steel, in which this firm specialises. Visitors should see the intricate pressing operation demonstrated on this stand to appreciate the value of deep drawing strip in reducing the number of pressings necessary. Those interested in pressings should see the elaborate display of articles manufactured from steel sheets, especially from the automobile body steel sheets and special heat-treated scaleless sheets shown by H. F. Spencer and Co., Ltd., the selling organisation for the Ebbw Vale Steel, Iron and Coal Co., Ltd. The specialities include motor body steel sheets of the highest quality, and surface finish for all outside pressed or straight panel work for modern motor-cars;



Two castings in the new metal, " Lepaz," produced by Leys' Malleable Castings, Ltd.

sheets for high-class steel furniture; special heat-treated scaleless sheets for deep drawing; sheets for vitreous enamelling; and high-grade C.R.C.A., P.C.R.C.A., etc., sheets for general press and sheet-metal work.

Of considerable interest to the manufacturer and user of alloy steel are the exhibits of High Speed Steel Alloys,

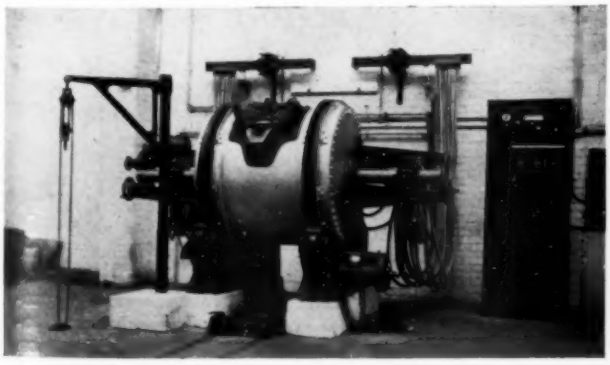
Ltd. The products manufactured by the firm are essentially raw materials utilised for the production of alloy steel and iron and other trades. The exhibits, therefore, are designed to show a full range of the firm's actual manufactures, together with examples of products in which these alloys are included. These products include ferro-tungsten, ferro-molybdenum, "Molyte," calcium molybdate, ferro-vanadium, and ferro-titanium; while the pure metals include tungsten and molybdenum powders, chromium, and manganese metals.

Salts and oxides of tungsten, molybdenum and vanadium, play an important part in manufactures. Most of these chemicals were previously obtained from the Continent, and can now be supplied competitively by this firm. They also show ammonium molybdate for use particularly in steel and other laboratories; a large range of metallic carbides suitable for various purposes, including hard-facing tools, etc.; and a self-fluxing rosin solder.

Test-pieces of a series of alloy steels of medium and high-tensile strength, carried out and certified by the Sheffield Testing Works are on view. This range of steels covers the requirements of engineers for many purposes. Examples also show the influence of alloy additions to cast iron, such as for rolls, camshafts, and motor-car parts, also fractures of alloyed pig irons.

Wrought Iron and Steel Tubes.

It can be said with truth that the uses of metal tubes are endless, new applications are being found for them every day. The uninitiated will certainly be surprised to see tubes in so many forms in different sections of the Exhibition, and it should be noted that they are not confined to round shapes. There are many manufacturers of this useful product, but the display of wrought iron and steel tubes by Stewarts and Lloyds should not be overlooked. The Chesterfield Tube Co., Ltd., exhibit cold-drawn weldless steel steampipes of various dimensions up to and including 24 in. internal diameter. Pipes of this description are in constant demand. Weldless steel headers of square and rectangular sections for boilers and superheaters are also included in the exhibit, together with weldless steel cylinders of different capacities for the storage of oxygen, hydrogen, nitrogen, carbon dioxide, acetylene, ammonia, nitrous oxide, chlorine, and sulphurous acid, etc. All cylinders are manufactured strictly in accordance with the latest British Specifications, also those adopted in foreign countries.



The new Birlec-Detroit rocking electric arc melting equipment, a product of Birmingham Electric Furnaces, Ltd.

Another interesting cylinder exhibit by this company are special lightweight alloy steel cylinders for storing coal gas at such high pressures as 3,000 lb. to 5,000 lb. per sq. in. Examples of "Feroma" tubes, which are manufactured from the latest corrosion and heat-resisting alloy steels, are also on view.

It is claimed that the range of utility of tubes is not fully understood until one has seen such specimens, illustrations of the ways in which tubes can be manipulated as are displayed by the Britannia Tube Co., Ltd. The varieties of cold-drawn steel channels and tubular sections regularly produced by this firm appear to have no limit in number, and their exhibit demonstrates their capacity for dealing with all possible requirements. Tubes, as they understand them, are drawn metal of so many other shapes than the plain round.

Installation of a No. 10 Atritor firing a reverberatory furnace suitable for melting pig or scrap iron. This furnace has a capacity of 12 tons per charge.

The stand of Accles and Pollock, Ltd., is built on the "Tubex" principle, which is now often used for showroom and stand structures. Here again the comprehensive exhibit of steel tubes of all kinds shows the amazing number of different trades to which tubular manufacturing methods have been applied. Quite apart from the purely engineering trades, we find tubes are put to such diverse purposes as toffee-making and soap manufacture, dairy and brewery equipment, caravan building and carpet-making, medical and dental apparatus, hair curlers and harpoons.

Iron and Steel Manufactures.

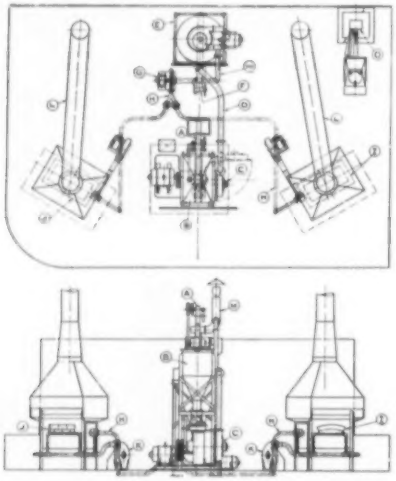
One of the many firms taking additional accommodation this year is Guest, Keen and Nettlefolds, Ltd., who are showing hundreds of samples of their various products, including screws, bolts and nuts, dynamo eye bolts, foundation bolts, plough bolts and nuts, rivets, bed screws, mattress bolts and keys, washers, drawbar pins for wagons, screw hooks, screw eyes and nails. A feature is made of hardened self-tapping screws, known as Nettlefolds and Parker-Kalon self-tapping screws, designed to facilitate constructional work in sheet materials of all varieties. This new product follows closely upon the now well-known hank rivet bushes, which were designed for providing deep tapped holes in sheet material. In addition to self-tapping screws, samples are also shown of hammer drive screws, hardened screw nails, and masonry nails, cold-forged thumb screws and cold-forged wing nuts.

An extensive range of perforated metals is shown by Messrs. G. A. Harvey and Co. (London), Ltd. The innumerable patterns needed for all kinds of sifting, sorting, filtering, and grading such diverse materials as coal, stone, cereals, food products, chemicals, etc., are amazing. In addition, this firm specialise in woven wire cloth in all metals and gauges, and the uses vary to a similar extent as perforated metal.

Considerable progress has been made in this country in recent years in the canning industry, and Messrs. Harveys' vertical processing retort exhibited will prove of interest to those connected with this growing industry. This firm specialise in the manufacture of plant needed in food manufacture, the chemical industry, and kindred trades. The firm also specialise in the manufacture of metal furniture, exhibits of which will be found of interest.

Malleable Iron Castings.

Despite progress in the use of other metals, malleable cast iron continues to find increasing applications. This is doubtless due to the care exercised in production by such firms as Ley's Malleable Castings, Ltd., Thos. L. Hale (Tipton), Ltd., and others, in maintaining consistent high quality. Many excellent examples of malleable castings are exhibited by these firms. Ley's "Black Heart" is manufactured under strictly accurate control of composition; its tensile strength is consistently regular at 24 tons per sq. in. Further, it is claimed that the free-



Layout of Atritor installation for firing forge furnaces, shown by Alfred Herbert, Ltd., on Stand No. D 404.

cutting properties due to graphitic carbon and absence of hard spots permit high machining speeds with reduced wear and tear of tools. The properties, combined with high resistance to shock, have led to the extensive use of malleable iron castings for an infinite variety of purposes where such mechanical attributes are in demand.

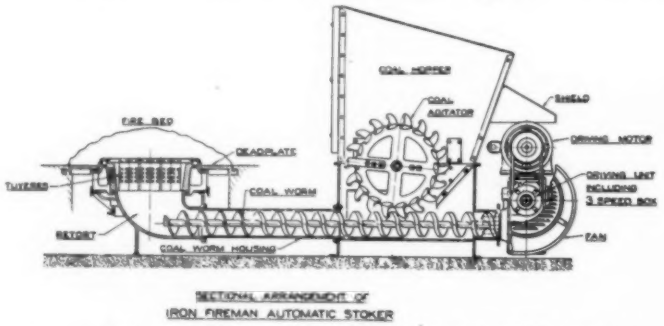
During the past year Ley's have introduced a new metal named "Lepaz," in the form of heat-treated alloy castings, with a high-tensile strength and ductility, fine machining qualities, and an unusually high resistance to abrasion, which especially suits it for use as brake drums and shoes, clutch drums and plate-chain units, elevator buckets, chassis brackets, and other parts subjected to friction or abrasion. In order to meet the increasing demand for their castings, the foundries of this firm have been considerably extended, and they are now considered to be the largest of their kind in Europe.

Another cast-iron product which will command much interest is exhibited by the Stanton Ironworks Co., Ltd. It consists of Stanton "Hard-Stud" road sections, cast-iron signs, etc. A stretch of Stanton "Hard-Stud" iron road has been included in the exhibition road laid at the entrance to the Fair by the Birmingham Chamber of Commerce, in order to demonstrate various types of modern road surfaces. The cast-iron sections each cover 1 sq. ft., and are laid on to a concrete foundation, over which has been squeegeed a film of bituminous grout. Diamond-shaped studs on the upper surfaces of the sections provide a non-skid tyre-tread, and at the same time form natural drainage channels. No fewer than 456,000 of these "Hard-Stud" road sections have been laid in the Mersey Tunnel, where they form the largest under-water highway in the world.

The surface of each stud is specially hardened by a special chemical process patented by the Stanton Company. This hardened upper layer offers a greatly increased resistance to wear, whilst high strength and resistance to shock are ensured by the tough backing provided by the more open-grained metal in the rest of the casting.

Protection against Corrosion.

Aluminium alloys so readily with iron that a direct hot-dipping process is not very successful, but cementation by means of aluminium is carried out, the process is known as "calorizing," and examples of this process are exhibited by the Calorizing Corporation of Great Britain, Ltd. The calorized coating is designed especially for service at high temperatures, where the aluminium acquires a resistant superficial film of oxide, which protects the article from further oxidation. Up to 900° C. the life of the coating is almost unlimited, and it is noteworthy that this coating also has the advantage of being resistant to attack by sulphurous fumes. Particular interest will therefore be taken in the exhibits of this Corporation, which include heat-treatment containers for casehardening, cyanide, salt and lead hardening, both in calorized pressed steel construction and in cast "Calmet" heat-resisting alloy, together with calorized solid-drawn steel pyrometer sheaths.



The iron fireman automatic stoker, shown by Alfred Herbert, Ltd., in section.

Further, a small section of a roof hanger assembly for oil-cracking stills will be shown, in which the tubes are supported by means of hangers from the roof, the tubes being of calorized weldless steel, and the hangers in "Calmet" heat-resisting alloy.

Cementation of iron by means of zinc, known as "Sherardising," is another method of protecting the surfaces of iron articles from the effects of corrosion, and examples of work treated in this way are shown by the Zinc Alloy Rust Proofing Co., Ltd. On view are various samples which have been treated by this process, including such fittings as gate and door furniture, hinges, electrical conduit, ornamental ironwork, and a general range of builders' ironmongery and engineers' stampings and forgings. An interesting item is a Sherardised steel casement, which has been rust-proofed entirely after assembly. This is a new development, which has been brought about during the last six months, and it will not be long before most standard sizes of steel casements will be rust-proofed after all welding has been carried out.

Non-ferrous Metals.

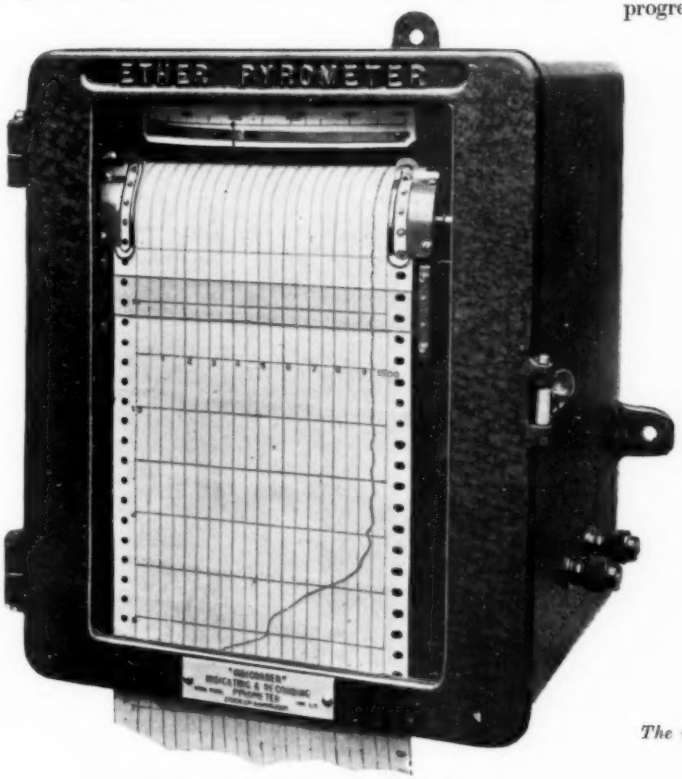
Although much attention has been given to the development of the iron and steel industry during the past year, progress has been steadily made in non-ferrous metal production. These metals have special advantages, and their uses, instead of diminishing as a result of the competition of ferrous materials, are finding increasing application. Copper, for instance, is not corroded by the action of the elements: it has a natural resistance to corrosion, since it develops an oxidised protective skin which greatly adds to the protection; this fact, together with its relatively low cost, is increasing its use for roofing and many other purposes subject to weather conditions.

The stand of I.C.I. Metals, Ltd., shows non-ferrous metals in sheet, strip, rods, tubes, plates, and wire, and two dioramas will demonstrate how extensively these products enter into modern life. For the first time, the exhibit will include such articles as copper rollers for calico printing, "Broduit" copper conduit tubing, "Broternal" condenser tubes, copper expansion joints, etc., which have

been brought within the range of I.C.I. metal products by the absorption into I.C.I. of two Lancashire firms—the Broughton Copper Co., Ltd., and John Bibby Sons and Co. (Garston), Ltd.

The use of " Acuro " copper tubes in making soldered joints should interest particularly those who are engaged in the building trades, and the offices and interviewing rooms will incorporate practical applications of I.C.I. metals for building and decorative work generally.

A wide variety of copper alloys is exhibited by McKechnie Brothers, Ltd. These include solid extruded brass, bronze, whitemetal and copper rods and sections, hollow extruded brass and bronze bars, hot brass, bronze and whitemetal stampings and pressings, anti-friction metals, zinc base die-casting alloys, terne metal, chill-cast phosphor bronze and gunmetal bars for bushes and bearings, gunmetal, phosphor bronze, brass, manganese bronze, and nickel-silver ingots, and granulated cupro-nickel and manganese copper.



A continuous recording pyrometer, by Ether, Ltd.

The extruded sections and hollow bars include many used by the shopfitting and allied trades, and the electrical and mechanical engineering industries, and show the degree of accuracy it is now possible to produce this class of material to. Hot-stamped parts in brass and bronze for automobile manufacturers and gas, water, and shipbuilding and mechanical engineers are also on view.

A comprehensive display of non-ferrous tubes is displayed by Serck Tubes, Ltd., who this year occupy a larger site to give a more adequate display of their manufactures, embracing many new sections which they have hitherto been unable to show. In addition are shown a full range of non-ferrous tubes in brass, copper, aluminium, gilding metal, bronze, tin, Admiralty gunmetal, etc., making a special feature of alloys which have been found to reduce to a minimum the corrosion met with in circulating and coiling plants.

For some time past this firm has made a feature of service copper of a very high purity, 99·9%; this copper is guaranteed suitable for bronze and copper welding, in addition to being made in a temper suitable for cone-joint fittings and manipulation without further heat-treatment. It may not be generally known, but this firm also specialises in very light gauge tubing to a wall thickness of five-thousandths, these tubes being used for aero and car-engine cooling. It is noteworthy, for instance, that this firm made and supplied the radiator fitted to Sir Malcolm Campbell's " Blue Bird " car.

Various types of non-ferrous castings are exhibited by Coventry Malleable and Aluminium, Ltd., including examples in aluminium, gunmetal, and phosphor bronze, such as crankcases, gearboxes, axle-cases, radiator tanks, oil pressure boxes, and other castings covering many industries. It is noteworthy that this company is displaying M.V. " C " aluminium-silicon alloy. This material is particularly suited for high-duty service, where high tensile and elongation are specified. This alloy is highly resistant to corrosion, and retains a high polish for an indefinite period.

Of the extensive and varied character of semi-finished non-ferrous material exhibited by many responsible and progressive firms, mention may be made of Messrs. Earle,

The immersion type of pyrometer for molten metal temperatures, by Ether, Ltd.

Bourne and Co., Ltd. These include brass, copper, aluminium alloy (" Sebalin " brand) in strip, sheet, tubes, angles, channels, sections, mouldings, and ornamental tubes; radiator sheets, plates and tubes, brass and copper film, special brass for the clock industry. Shop-front metals, cased tubes, square tubes, bends and top rods. Domestic water service copper pipes and syphons and condenser tubes; a comprehensive range which is typical of many non-ferrous metal manufacturers represented at this exhibition.

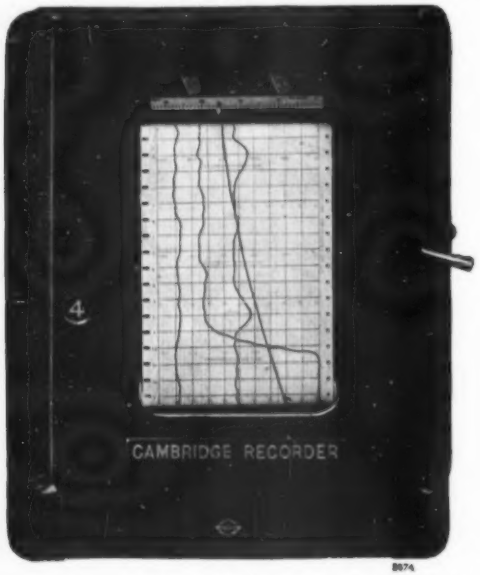
Melting Furnaces.

There is apparently fewer melting furnaces exhibited this year, but the new " Birlec-Detroit " rocking electric arc melting equipment shown by Messrs. Birmingham Electric Furnaces, Ltd., will attract much attention. By an agreement between Birmingham Electric Furnaces, Ltd. and the Detroit Electric Furnace Co. this equipment is now entirely British made for users in the British Isles, the Dominions, and certain other countries. This furnace is well known in the United States, but this is the first time it has been exhibited in this country.

The advantages of this furnace for ferrous and non-ferrous foundry purposes can only be mentioned briefly here, but visitors should inspect it. The arc is formed on

the axis of a horizontal cylindrical chamber which is rocked about its axis continuously during melting. In this way exceptionally rapid heating of the metal is obtained. The rocking action of the chamber also has the important effect of ensuring strictly uniform distribution of all constituents throughout the metal, so that the product is absolutely homogeneous and free from local defects of any kind. This fact, of course, represents a genuine economy by making possible the production of an improved quality of metal with much greater consistency, but it should also be remembered that it will melt charges of cheap scrap material, such as borings, turnings, etc., with negligible loss, so that a further important saving may be effected in this way.

In general, this furnace is noteworthy for reducing metal



A temperature recorder by Cambridge Instrument Co., Ltd.

losses, ensuring uniform composition of the melt, providing a rapid output of metal and permitting exceptionally accurate control. Over six hundred of these equipments are already in use in brass foundries and in the production of high test, malleable, and other special grades of cast iron

Pulverised fuel is being increasingly used for heating furnaces for various purposes, and visitors should see the application of a No. 6 Atritor, which is shown in operation firing two forging furnaces, one for heating small bars for the manufacture of bolts and rivets, and the other for general forging and stamping work. A Redler elevator is used to transfer the coal to an overhead bunker and thence to the Atritor, which dries, pulverises, and discharges the coal into a cyclone separator, the coal falling into a receiver and the air passing to a bag filter or to the primary air fans as desired.

A feeder, which for the purposes of the demonstration can be switched from one furnace to the other, is driven by a variable-speed motor and delivers the pulverised fuel to the burner of the furnaces. The temperature of the furnace can be easily controlled by varying the speed of the motor. Each furnace is provided with a motor-driven fan, the speed of which can be adjusted to give the proper proportions of pulverised coal and air to ensure the most efficient combustion.

This arrangement of firing pulverised fuel can be extended to five or six furnaces, one Atritor of suitable capacity being used. Each furnace can be controlled independently and conveniently by the operator. This Atritor coal pulveriser is exhibited by the manufacturers, Messrs. Alfred Herbert, Ltd., and is one of the many interesting features on their stand.

Heat-treatment Furnaces.

Heat-treatment is a vital operation in the fabrication of most metal parts, which have to possess certain desired properties. Definite fundamental principles are involved in the apparently simple heating and cooling of the metal or alloy, and unless these parts are understood and followed grave damage to the finished article and loss may result. The process consists in subjecting the article to a definite temperature versus time cycle, which is necessarily divided into heating up, maintaining the temperatures, and cooling off. One of the first considerations is the type of furnace suited to the particular needs.

Among the exhibits of heat-treatment furnaces, much interest is attached to a continuous belt-conveyer furnace for brazing in an artificial atmosphere, for bright annealing and similar operations. Electric furnace brazing is a process which is also at present more largely employed in America than in this country, but its remarkable advantages are securing for it already very favourable notice among many progressive firms in England, and should therefore ensure considerable interest in this working demonstration of the process.

The furnace, which is exhibited by Birmingham Electric Furnaces, Ltd., is generally similar to a type which has been manufactured by this firm for some years past for bright annealing, and employs a wire mesh conveyer belt for carrying the work consecutively through the heating and cooling chambers. These chambers are maintained filled with an artificial atmosphere which prevents oxidation of the work and allows the brazing material to flow smoothly over the metal without the use of any flux. In this way the brazing compound—usually copper or brass—penetrates to every part of the joint and makes the assembly virtually a single piece, however complicated its components, without the necessity for any manual operation, and without setting up any strains in the materials.

In addition to the foregoing important working exhibits, a small forced-air circulation low-temperature furnace for tempering and similar processes will be shown, while photographs and technical data will be available dealing with a very wide range of Birlec industrial installations covering practically the whole field of heat-treatment and melting.

William Allday and Co., Ltd., are exhibiting a number of furnaces which include a new type of twin-chambered, oil-fired, tool-hardening furnace, particularly suitable for high-speed steel tools. Another noteworthy exhibit is an entirely new oil-burner outfit, suitable for general heating work, operated by compressed air. It is mounted on a truck, with provision of oil to last a full working day, and is readily transported. On the same stand is a new type of hot brass stamping furnace made by A. H. Wilkes and Co. It is equipped with single-cock control gas-and-air blast burner, which automatically proportions both gas and air supplies.

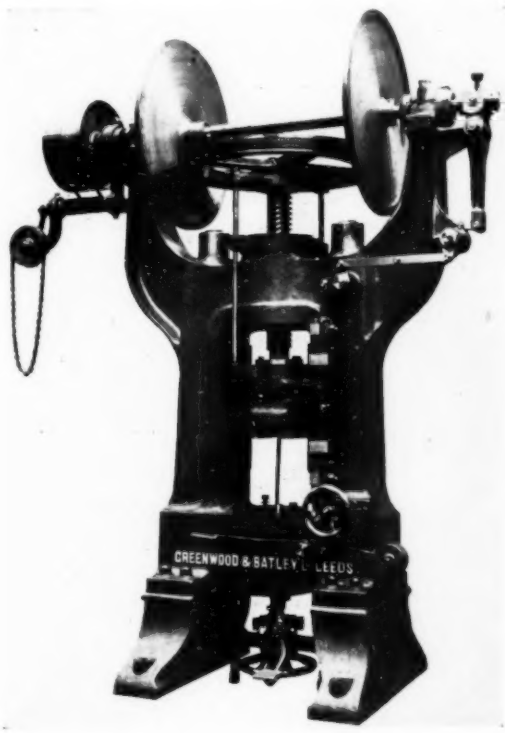
The Cassel cyanide case-hardening exhibit will include gas and oil-fired furnaces, one of them much larger than the general run of cyanide furnaces in this country, and designed for the heat-treatment of big jobs or of small articles in large quantities. This furnace, and two others, will be working to give demonstrations of case-hardening and heat-treatment with cyanide and "Rapideep," the recently developed deep cementation compound. "Rapideep" is suitable for use in the ordinary case-hardening bath, and is particularly useful where distortion is absolutely unavoidable. The cases produced have the advantage of being glass hard for over half their depth, so that deep grinding can be carried out without exposing soft material.

Imperial Chemical Industries, Ltd., show the "Drikold" shrinking bath, which has been introduced since last year's exhibition, but has already been successfully employed in a variety of engineering uses. By the use of this bath to obtain shrink fits, the normal procedure of expanding the outer member of two parts to be assembled is reversed.

The inner member is cooled and contracted by utilising the low temperature of solid CO_2, and after assembly is allowed to expand as it heats up to atmospheric temperature. The advantages of the process, besides low capital cost, are that fully machined and polished parts can be easily and rapidly assembled without damage to the finish, without distortion, and without abrasion taking place. Moreover, previously heat-treated parts can be assembled without disturbance of their crystal structure.

Temperature Measuring and Control Equipment.

In view of the attention given to controlled heating and cooling of metal products during recent years, it is not surprising that much equipment to facilitate these operations is on view at this exhibition. A very comprehensive



A screw press fitted with automatic braking, by Greenwood and Batley, Ltd.

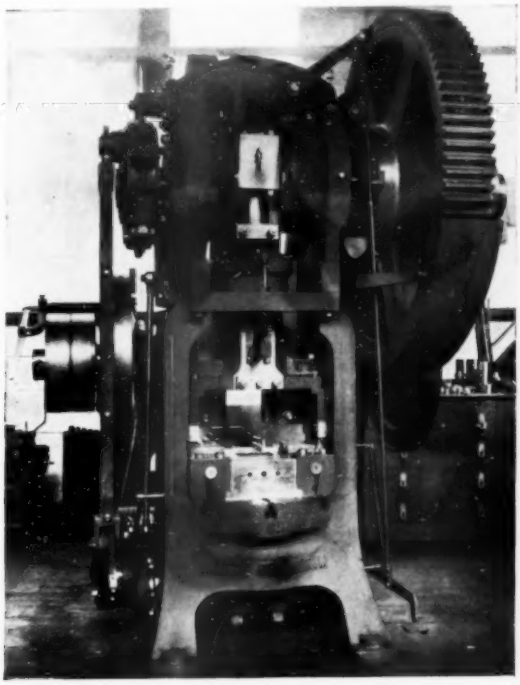
selection, for instance, is shown by Cambridge Instrument Co., Ltd., which includes all kinds of temperature measuring and controlling instruments, electrical measuring instruments, apparatus for use in connection with power plant, engineering and mechanical work, gas analysis apparatus, and physical measuring instruments. The range of instruments is so wide and varied that it is impossible in this survey to deal with them, but considerable reference to some of the instruments exhibited was given in our last issue.

A new feature is exhibited by Messrs. Ether, Ltd., which comprises a new patent eccentric movement fitted to the various temperature indicators, recorders, and controllers displayed by this firm. This new system has been developed during the last few years, but it is exhibited for the first time this year. It is claimed that this design is free from error, due to temperature changes; it prevents sticking due to friction; it is robust in construction, and yet is remarkably sensitive. The range of instruments featured by this firm is very considerable, and they should be examined with a view to making comparisons with other makes.

Several new instruments are shown by Foster Instrument Co., which includes a new continuous chart recorder of the direct deflection type, providing an open record on a 7-in. chart without the complication of the potentiometric method. The instrument is available in flush fitting or projecting cases, has a vibration and shock-proof movement, and the electric clock drive for operation off 50-cycle A.C. supplies is provided with change mechanism whereby two chart speeds can be obtained. Up to six records, each in a different colour, can be recorded on the one chart, and a double-pole commutator of the sealed mercury tube type is utilised.

Pressing Machines.

So much work is accomplished by presses in modern manufacture that considerable attention has been given to these useful machines, and to-day the criticism formerly directed against British presses does not stand. Several presses are exhibited and demonstrate their usefulness on different material. Messrs. Taylor and Challen, Ltd., for



An automatic four-way pressing machine shown by Taylor and Challen, Ltd.

instance, show an automatic four-way core-pressing machine, specially designed for the brass foundry trade. This machine presses at one operation such articles as pipe unions, taps, cocks, etc., from a billet sawn off extruded rod of brass of the normal hot-pressing qualities; the only finishing operations are the clipping of a flash which can be kept very thin, and finish drilling through of the cored ways. A 200-ton crank press is used, running at the high speed of 40 strokes per min., and the squeezing action has a very good effect upon the internal structure of the metal. Other machines shown include a new high-speed armature notching press, and a double-action drawing press with a stroke to the punch of 24½ in.

Greenwood and Batley, Ltd., are exhibiting a 125-ton screw press fitted with automatic breaking at the top of the stroke and foot and automatic ejection mechanism. In addition, this firm show a 1½ in. hot-forging machine and a trimming press of 25 tons capacity. All these machines are independently driven by "Greenbat" electric motors, and are on production work on the stand.

A comprehensive range of sheet-metal working machinery is exhibited by F. J. Edwards, Ltd. These include guillotine shearing machines for power and treadle operation, a 6 ft. × 14-gauge high-speed power guillotine is in operation as one of the exhibits. Throatless or irregular shearing machines; hand-operated interior cutting machine; and a universal shearing machine is under power. This latter machine has

a 30-in. throat and a capacity for shearing up to 14-gauge mild steel. Straight or irregular outside or inside cutting can be done on this machine, and no holes require to be drilled for starting inside work.

Electro-Magnets.

The increasing use of electricity has given an impetus to the use of apparatus and appliances in which the advantages of this form of power have a special value. Of particular interest are the many types of magnetic devices, such as magnetic separators, extractors, lifting magnets, clutches and chucks used in both the ferrous and non-ferrous trades, and suitable for treating material from the ore stage to the finished product. At this exhibition Electromagnets, Ltd., are demonstrating many of their smaller types of separators, scrap testers for treating swarfe, scrap and casters' ashes; other machines for treating foundry sand are shown, together with stationary chute, vibratory and jig shaker magnet for treating liquids, powders, semi-solid and lump materials. This firm also

An oxygen cutting machine exhibited by British Oxygen Co., Ltd. It is particularly suited for either small or large work.

show a laboratory ore tester. These machines have a special economic value, and should be inspected.

Another firm exhibiting various designs of electro-magnetic separators, lifting magnets, scrap-sorting magnets, chucks and clutches, is the Rapid Magnetting Machine Co., Ltd. A new drum type separator used for separating loose iron and steel from swarfe and borings is on view. The drum in this machine embodies the specially designed magnetic unit, which is so arranged that the iron and steel held against it gambols through alternate magnetic polarities, thus ensuring a thoroughly clean separation. The framework, however, has been modified: it is lighter, more compact, and the arrangement of driving the drum from the main shaft is by means of a "Whittle" or "V" belt. Several new developments are exhibited by this company.

Foundry Machines.

Representative foundry equipment is exhibited by Pneulec, Ltd., who demonstrate moulding and sand-preparing machines.

The moulding machine is of the jarr roll-over pattern draw type, with the rolling over and pattern-drawing operations controlled by oil. The machine demonstrated has a turnover plate 20 × 36, and a capacity of 750 lb. It is the smallest of this series machine, which is available in sizes up to the 8 ft. × 10 ft. table 20-ton capacity machine. An interesting feature proving the accuracy of the machine demonstrated is that the mould can be put back on to the pattern and stripped again without sign of a crush.

Of their sand-preparing machines, Pneulec are demonstrating the "Royer" sand mixer and "Silkysand" disintegrator. The Royer is a general utility machine, and has been widely adopted. The Silkysand is a disintegrator which produces the finest grade of facing that could be required, and the design eliminates any possible breakdown due to scrap in the sand.

Welding Equipment.

In the section devoted to oxy-acetylene welding and cutting, all the well-known types of British Oxygen Co. blowpipes may be seen. Here, progress is represented more perhaps in the development of welding techniques than in the design of equipment, although keen eyes may observe minor refinements which have been made since February, 1934. Therefore, the demonstrations of copper welding with a 3-jet nozzle, of rightward welding, the bronze-welding of joints in copper piping (of particular consequence to plumbers, and to water and heating engineers), and of welding with a 2-jet nozzle, are of more than usual interest and value. The surfacing of rails with a 3-jet nozzle using the "Alda" wear-resisting alloy steel rod will be a special feature of this section. In addition to these demonstrations, visitors may see oxygen machining, lead-burning, and metal-spraying demonstrated.

Those interested in oxygen cutting machines will find that various improvements have been effected in the design of B.O.C. machines. The largest machine which will cut any shape within a semi-circle of 55 in. radius from steel up to 15 in. thick, now incorporates the latest practice as regards heating the oxygen supply, and also as regards balancing the cutting arms. The latter gives ease and responsiveness of operation. Controls have been grouped as a further aid to the operator.

The value of electric arc-welding for structural engineering will be appreciated by the exhibits in the section devoted to electric arc-welding. Ferro-arc electrodes suitable for this class of work will be tested by actual demonstrations.

Messrs. Holden and Hunt are this year again showing a very complete range of their electric (low voltage) resistance welding machines, these of the spot, butt, and flash-butt types. All the machines are shown in operation. A new development is a No. 6 overhung long-arm type spot welding machine, which is entirely electrically operated, and controlled by a foot- or press-switch when the welding pressure is exerted magnetically, and the weld duration controlled through a variable electronic timer, with the welding current through high-speed contactor switches, also the machine can be arranged as a high-speed stitch welder, when the operation is by press-button. There are several outstanding features of the machines displayed by this company, but they should be seen to be appreciated.

A BRAKE drum liner which has been in service in the wheel-brake of a motor lorry for 150,000 miles, shows very little wear. Although a certain amount of scoring was noticeable the thickness, as measured by the micrometer, was only reduced from 0·171 in. to 0·157 in. This liner was made by Walker Steel Works, Ltd., who make a speciality of brake drums, brake drum liners, clutch-plates, and clutch-plate facings in their Walloy nickel alloy cast iron.

The superiority of cast iron as a braking medium, due to its high coefficient of friction, is generally recognised, and to give greater resistance to the conditions of extreme wear and to the high bursting stresses which accompany hard braking, brake drums of nickel cast iron have been widely adopted, especially in commercial vehicles.

Development in Manufacture of Seamless Tubes

By Gilbert Evans

The author discusses the latest American developments in the reduction of diameters and wall thickness of tubes, and places on record his appreciation of the Foren process, which is based on the principle of kneading the material. As a result of recent developments the author asks, "has perfection been attained in the manufacture of seamless tubes?"

A DISTINGUISHED authority on the subject of manufacture of non-ferrous tubes, gave it as his considered opinion that "as long as tubes of varying alloys are made, so long shall we have casting on sand or solid cores" to form the basis of the finished article. With the great advance in methods during comparatively recent years, one wonders (except in the case of the smaller manufacturers) from what point of view he considers that considered opinion at the present time. No other branch of trade can produce evolution comparable with the intricate processes of tube manufacture. The old fashioned—and in their day—standard methods of casting solids or hollows and boring and turning for concentricity surface perfection together with casting on sand cores have been superseded by the rotary piercing and reducing mills, and the extrusion press processes. In the casting of solid billets for either of these methods the cannon type of mould is slowly but surely being replaced by the water cooled design, which, in addition to an improved surface, produces a billet of finer grain structure. Reverting for a moment to the steel-tube trade, it was as recently as 1907, a recognised fact that Swedish charcoal steel was the only material adaptable to the intense strains set up in piercing by Mannersmann and Stiefel Piercing apparatus. To-day there are at least a score of British steel manufacturers who provide billets suitable for the purpose, in qualities up to 0·6 carbon.

Progress under a combination of technical and practical experience has triumphed over all difficulties, as has been the case in the brass, copper and non-ferrous alloys tube trade. It may not be common knowledge that large diameter tubes are manufactured from solid billets of much smaller diameter than the finished article by a secondary process which will be self explanatory when described as expanding. The author speaks authoritatively, having been responsible for the first step in this development, in which a 7-in. solid billet was pierced over a 6¾-in. plug: reheated and subjected to a first expansion over a 9-in. plug and finally over an 11½-in. plug to be finally cold drawn to 12 in. inside diameter × ¼ in. walls: with a length of 20 ft. 0 in. These were exhibited at an exhibition of the non-ferrous trades at the Agricultural Hall, London, in about 1910, and at Buenos Aires exhibition a year later, creating great interest. One may mention that on the same stand small tubes were exhibited in contrast of such a minute bore that, in order to convince the sceptical that they were really hollow, it was necessary to insert one end in a glass of water and blow through the tube to create bubbles as proof that they were tubes. Tubes of these small sizes with very thin walls are in great demand by manufacturers of optical goods; they are difficult to obtain on account of great cost of manufacture and very few firms will undertake to supply. In those days they were made from scrap ends of condenser tubes ¾ in. and ⅝ in. × 16 and 18 i.w.g. To-day, with the production of shells by extrusion from the solid down to ⅜ in. × 16 i.w.g., the cost of making is greatly reduced, but is still recognised as a special branch of tube manufacture.

This lengthy introduction to this treatise has been rendered necessary owing to the latest American developments in the reduction of diameters and wall thickness of tubes, a corollary to the advance in the other direction—viz., expanding already referred to, and the object of the author is to briefly place on record appreciation of the commercial success of the Foren rolling mill patented in America May 17, 1933, Registration No. 1,858,990, and in Great Britain under application September 7, 1931, which patent, No. 393,636, was completed and accepted June 7th, 1933. This process, invented by Peter Alfred Foren, of Milwaukie, State of Winconsin, U.S.A. is based on the principle of kneading the material, a term descriptive of a principle recognised as forming the practice of subjecting the metal to pressure between solid surfaces at different points, as is recognised in the rolling of solid non-ferrous metals. The term "kneading" is conspicuous in the inventor's specification, and which the author now proceeds to briefly review.

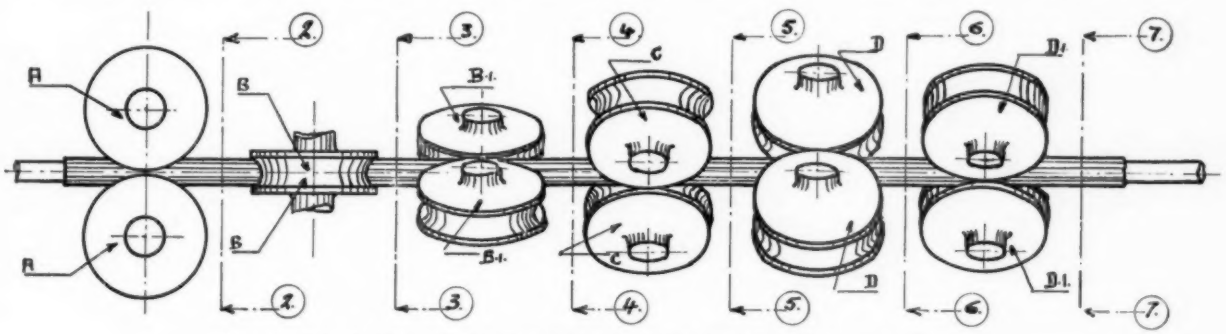


Fig. 1.—Side elevation showing the principle of P. A. Foren's rolling process for tubes.

The solid round billet is cast by standard accepted methods, and without cooling is conveyed to a reheating furnace in which it is brought to a metallurgically correct temperature for piercing in a rotary piercer to a required inside diameter and wall thickness. On the completion of the piercing operation the hollow shell is transported by suitable means to the Foren Mill which operates at a very high speed—*viz.*, 17 ft. per second, or 1,020 ft. per minute. A solid bar or mandrel of special alloy steel, accurately ground and hardened and considerably larger than the hollow shell, is inserted in the inside, and the

mandrel and shell are inserted into the actual working rolls. Figs. 1 and 2, show top and bottom working rolls A, arranged and rigidly supported and driven for rotation in a vertical plane. The second pair of working rolls B, see Figs. 1 and 3, are arranged and rigidly supported and driven for rotation in horizontal plane. The third pair of rolls B1. (Fig. 1 and 4), are supported, but not necessarily driven, being used to reshape the blank to render it symmetrical with respect to the pass of fourth pair of rolls C. The fourth pair of rolls C (Fig. 1 and 5), are rigidly supported and driven for rotation in a plane at 45 ° angle. The fifth pair of rolls D (Fig. 1 and 6), are rigidly supported and driven for rotation normal to plane of C. The sixth pair of rolls D 1. (Fig. 1 and 7), are rigidly supported and

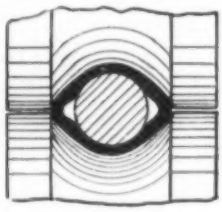


Fig. 2.—Rolls A.

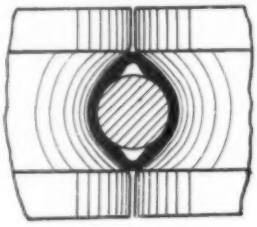


Fig. 3.—Rolls B.

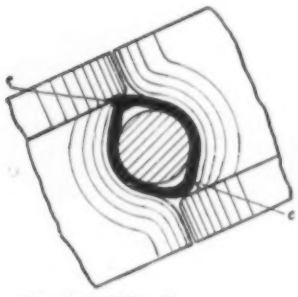


Fig. 4.—Rolls B1.

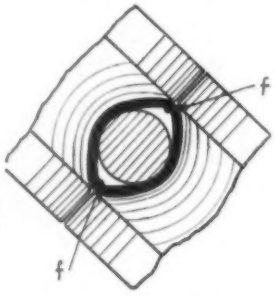


Fig. 5.—Rolls C.

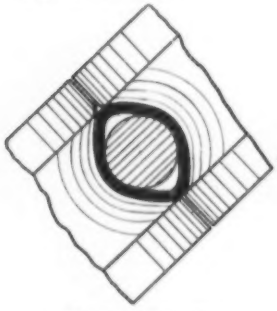


Fig. 6.—Rolls D.

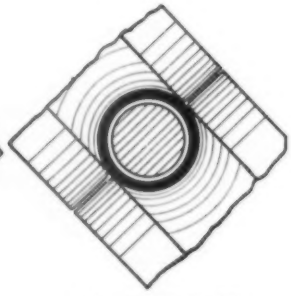


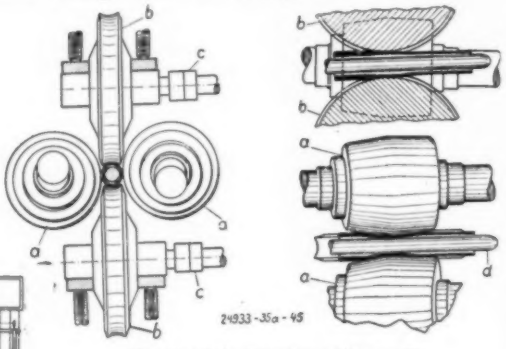
Fig. 7.—Rolls D1.

These correspond to similar rolls shown in Fig. 1.

preferably power driven. These rolls complete the perfect circles of the tubes inside and outside diameters, and in their operation distribute the sectional area of the metal so that the tube is entirely released from the solid inside mandrel.

In order to encourage lengthening process, each pair of rolls B-B : C-C : D-D : is driven at a greater speed than the immediate driven pair. It will be noted that in each of the actual working or kneading rolls A, B, C, and D only a certain cylindrical portion of the material is operated on by the pressure between the rolls and the solid inside mandrel, but that in the passage of the shell and mandrel between rolls A, B, C and D, the whole outside and inside circumferential surfaces are brought under the kneading pressure. The rolls are located at 22·5 ° on each side of the vertical and horizontal planes, giving a centre line of working contact for every 45 ° of tube circumference, as compared with 90 ° in generally accepted practice. This arrangement permits an actual working contact by each roll of half the length of contact common in other equipments, and since no working point of the roll groove is more than 45° distant from the centre of the groove, speed interrelations between the different points on the working contact of the groove are claimed to be superior to those obtained with pairs of rolls disposed at 90 ° to each other, a state of affairs resulting in less wear on the rolls and a considerable saving in power due to elimination of excessive slipping and consequent friction between rolls and material being rolled.

A comparison of rates of output in actual tubes with the productive power of the Pilger mill or step by step rolling is greatly in favour of Foren's Mill—viz., six tubes 40 ft. 0 in. long as compared with 2½ tubes per minute on the Pilger Mill. The rolling process being completed and with no interruption of direct progress, the end of the solid internal mandrel is gripped by a set of jaws, while three sets of stripping rolls remove the rubes from the bar, passing it on when required to further manipulation to a series of reducing mills or if the tube is of the desired dimensions transfers it to a cooling table, while the mandrel is by automatic means transported to a cooling water bosh and



Details of the Diescher rolling mill.

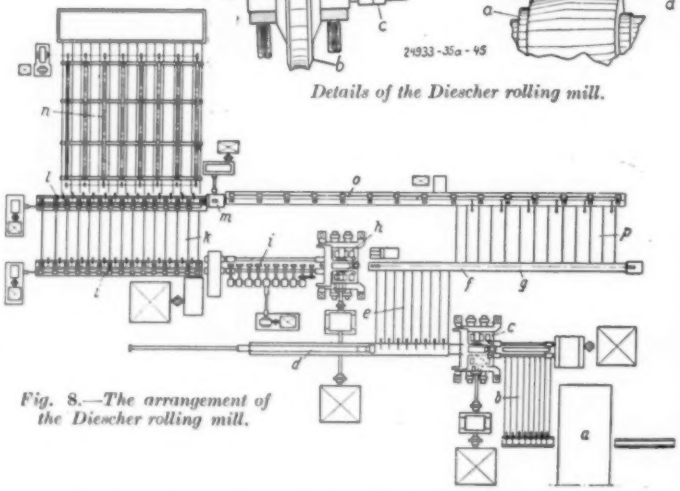


Fig. 8.—The arrangement of the Diescher rolling mill.

thence is conveyed to its original position ready for a further operation. A number of mandrels of the same diameter are used in rotation which allows for the necessary perfect cooling before being again put in to use. In further comparison with the Pilger process it is possible to manipulate the hollow pierced shell in to a tube with 16 or 18 i.w.g. wall thickness, whereas in the first named Mill an average wall thickness of 10 to 12 i.w.g. is necessary, so an article is produced which compares most favourably with the products of the most advanced extrusion practice.

As is usual in tubes finished by the hot rolled process, with elastic limits in regard to the required diameters, tubes produced in the mill under review require very little treatment in cold drawing to finish inside the most rigid limits, and so where cold drawing is insisted on the most expensive items in manufacture—viz., heat treatment by annealing and subsequent cleansing of the surfaces by pickling are reduced to a minimum, as also is straightening.

Under microscopic examination etched specimens of tubes made by the different processes, the products of the Foren Mills show a much finer grain structure, and improved surface entirely free from such mechanical defects as scratches and waves, the latter due to chattering in rolling

(*Continued on page* 34.)

The Welding of Iron and Steel

The importance of the application of welding to various constructions has attracted the attention of many investigators and responsible technical bodies in this country and abroad. In this article the symposium on welding, which reveals the research work relating to welding in progress, is reviewed.

IT is doubtful whether a more comprehensive consideration of welding, in its application to the iron and steel industries, has ever been presented before a technical gathering than that embraced by the Symposium presented in the Great Hall of the Institution of Civil Engineers, on May 2 and 3. Organised by the Iron and Steel Institute in co-operation with a number of other technical societies, this Symposium comprises a very thorough examination of the subject in its application to practically every section of industry using iron and steel. Every conceivable aspect seems to have been under survey, and the organising committee are to be congratulated on the manner in which information on the subject has been collected. Some indication of the thoroughness of the exploration may be gathered from the fact that the Symposium embraces 146 papers, but the fact that there is relatively little overlapping gives a better idea of its comprehensiveness. During recent years there has been rapid progress in the application of welding to all forms of structures. Each new application has invariably been preceded by investigations in an endeavour to understand as fully as possible the effect of applying the process ; the primary object being to remove doubts which usually arise with any new application and to determine the extent to which the process could be used without reduction in the security of the structure. Considerable investigatory work has therefore been carried out, and with increased experience of the process fuller knowledge has been obtained of its advantages and disadvantages, for long, however, there has been a special need for a comprehensive survey of the subject, and this Symposium supplies that need. The value of this work will be readily appreciated when it is realised that the papers are not confined to experience and investigations in the United Kingdom, but include the results of investigations and practice in other countries within the British Commonwealth, from Austria, Belgium, Czechoslovakia, France, Germany, Holland, Poland, Sweden, and the United States.

The subject has been considered under four main groups : Group 1 dealing with present-day practice and problems of welding in the engineering industries ; Group 2, welding practice and technique, including welding apparatus ; Group 3, the metallurgy of welding ; and Group 4, specification, inspection, testing, and safety aspects of welding.

Present-day Practice and Problems of Welding in the Engineering Industries.

(GROUP 1.)

The group embracing present-day practice and problems of welding, because of the wide field covered, has been divided into two sub-groups, each covering special sections in the engineering industries. The first of these sub-groups, which was presented by Dr. S. F. Dorey, contains various aspects of welding as applied to bridge and structural engineering, pressure vessels (including boilers, pipe-lines, tubes, tanks, and vessels for use at high temperatures and pressures), railway material and shipbuilding.

SUB-GROUP (*a*)

The application of welding to bridges in this country is only in its infancy, but in many other countries certain advantages the method possesses have led to its greater use. In Australia, for instance, Mr. W. T. B. McCormack points out that the freight charges for transporting on the railways, being based on the value of articles carried, provide a freight cost on fabricated steel of about double that for the unprepared sections direct from the steelworks ; it is not surprising, therefore, that this has influenced engineers in developing structural work on a simple bases where the assembly and the fabrication can be completely carried out in the field. This fact alone had much to do with the development of welding in its application to bridges, and Mr. McCormack gives data of a number of bridges in which welding played a prominent part. According to Messrs. Atkinson and O'Malley, the Railway Construction Branch of the Board of Lands and Works, Victoria, Australia, has, since 1925, made use of electric arc welding in the construction of new bridges and the reconditioning and strengthening of existing bridges to carry railway and highway loading. The first serious application of welding to repair and strengthen a railway bridge was carried out more or less as an experiment, but it proved so successful that confidence in welding for the more important parts of bridge work developed rapidly, and its use was extended to all forms of structural work in which estimated savings could be made thereby. The authors of this paper describe important features in many bridges constructed with the help of welding.

According to Dr. Ing. Schaper, who discusses welding in building and bridge work, building structures of every kind which are not subject to large dynamic stresses, such as office and factory buildings, signal gantries, water-towers, station and platform roofs, can be welded without hesitation, whether in solid or in truss construction. Highway bridges, in which the dead loads are large and where maximum live loads seldom occur, can be welded without hesitation in the case of solid construction, and also in truss construction under certain conditions. In the main, this also applies to railway bridges, with the exception of truss construction, which, the author states, is at present not justified by the results obtained from fatigue tests.

One of the objects of this Symposium is to reveal what research work relating to welding is in current progress ; with this in view Dr. H. J. Gough summarises the history and research activities of the Steel Structures Research Committee as far as welding is concerned. In this paper attention is mainly devoted to a statistical examination of the strength of welded connections for structural purposes, made under practical conditions of control and supervision, according to a proceedure and to forms laid down by the Committee. Some attention has been given to an examination of non-destruction field tests for welded structural joints.

There is probably no industry in which so many different varieties of shapes and designs are encountered as the chemical industry, and, when such conditions occur, welding, where possible, is the most convenient and cheapest method of construction. This aspect of welding is discussed by Messrs. N. P. Inglis and W. Andrews, who survey the application of welding to the very wide field involved in that industry.

There are approximately forty papers in this sub-group in which all the method of welding available to-day—oxy-acetylene, electric arc, carbon arc, forge, resistance, etc.—are discussed in relation to different types of structures.

SUB-GROUP (*b*).

The second of these sub-groups, which was presented by Professor B. P. Haigh, is concerned with the application of welding to the aeronautical, automobile, chain, electrical engineering industries, to heavy engineering, and machinery manufacturing industries (including marine engineering), and iron and steel castings and wrought iron.

The conditions under which welding is permitted throughout aircraft structures is reviewed by Mr. H. Sutton, of the Royal Aircraft Establishment. No objections are raised providing the strength properties of the material before and after welding are known and are adequate for the loads involved; the other properties of the material before and after welding are satisfactory; and the inspection procedure is such as to ensure that the strength of the worst weld accepted as complying with the type design will meet all specified strength requirements in full. Different welding processes are discussed and welds in varying types of steels.

The application of welding in the manufacture of American aircraft is reviewed by Mr. J. B. Johnson, who states that welded steel construction reached a peak in 1931 and 1932 when over 75% of the aeroplanes manufactured in the United States had welded steel fuselages. Since that date monocoque designs employing a stressed skin of aluminium alloy have been developed and are displacing the welded fuselage.

In few industries has the art of welding played a more important part than in the manufacture of all-steel automobile bodies, and Mr. J. C. Arrowsmith reviews this applicatiod. Other aspects of the use of welding in the automobile industry include the welding of chassis frames by Mr. H. S. Bavister; welding in relation to automobile and general repair work by Mr. C. W. Brett; and welding practice in Australian automobile manufacture by Mr. F. S. Daley.

Since electrical developments have contributed in no small way to advances in the art of welding, it is natural that the products of electrical engineering have been a primary testing ground for welding developments. The fulfilment of their intended purpose through continued service has fully justified the employment of the processes; indeed this may be said of most of the applications now in use. Several papers in this section deal more particularly with the application of welding to the electrical industry; thus, Messrs. H. W. Hawkins and J. Donkin briefly survey the history of the art, applications, advantages, developments, and future potentialities as regards the products of metallic-arc and electric resistance welding in the manufacture of electrical machinery and apparatus; Mr. E. C. Davies examines the characteristics of welded electrical components as compared with those produced by other processes; and Mr. J. A. Dorrat discusses the application of electric welding in the fabrication of plant and machinery. It is noteworthy that the underlying fundamental principles of design, process and manufacture, apply equally to the products of any other industry, the difference being only in the technical requirements of the particular product.

In marine engine-building violent breaks with tradition are seldom found, and progress is best made on sure foundations. This is especially true of the application of welding, which has been a useful tool in that section of the industry which deals with repairs for about twenty-five years. In the building of new work the history is shorter, but the number of applications which have been found for it is very much greater. Dealing with welding in its application to marine engineering, Dr. T. W. F. Brown states that the application of welding and its acceptance by owners and the registration societies, depends on building up confidence. The use of electric-arc welding in the construction of marine engine frames is of comparatively recent date, and Mr. C. H. Stevens discusses this application. There can be no doubt, as Mr. E. F. Spanner states, that metallic-arc welding, oxy-acetylene welding, and all forms of resistance welding are destined to play increasingly important parts in marine engineering.

Welding Practice and Technique, Including Welding Apparatus.

GROUP 2.

Up to the present there has been too much disagreement about different processes of carrying out the same welding operation, because the characteristics and peculiarities of each were either not known or insufficiently known. It is necessary to examine them together and with all the requisite technique to understand the respective advantages presented and the different uses it is desirable to make of them. Several processes may be adopted to fulfil one operation; it is therefore necessary to study each separately to make comparisons and thus assist the choice. This group is concerned primarily with the practice and technique of welding, and it was presented by Dr. A. McCance. It embraces some twenty-five papers by investigators on various aspects of welding.

It is generally recognised that the building up of a satisfactory technique is the outcome of investigations carried out at the test bench with the modifications found necessary by experience when welding actual constructional work. It is a slow process, and reasonably so when it is remembered that, after all the years in which riveted structures have been built, problems still arise on which very little information is available. It will be appreciated that the present-day structural drawing office, with its personnel educated and trained to the ordinary methods of riveted construction, has a specially difficult task in presenting an entirely new technique for welding. The temptation to improvise on existing riveted details is bound to exist, and it is only by guarding against this tendency that real progress in the new science will be made.

Although remarkable strides have been made in the knowledge of welding and the extension of its applications, it is estimated that not more than 25% of the possibilities of welding have been fully explored. This is not at all strange when one considers the complex metallurgical problems and the large number of variables generally involved. Good results in any specific case may usually be obtained in a variety of ways, and the experience represented by the papers in this group will undoubtedly assist. In addition to papers by well-known authorities on welding practice and technique in different welding processes, several papers deal with problems arising from welding; thus, Messrs. L. E. Benson and H. Allison consider the low-temperature annealing of welded mild-steel structures to relieve internal stresses; Messrs. D. Boyd and G. Cape, of Canada, discuss distortion control procedure; Mr. J. A. Dorrat reviews welding practice and methods of avoiding distortion in welded structures; and Messrs. P. W. Townsend and A. L. Whiteley each consider the control of resistance welding. This group also includes a number of papers from authorities in foreign countries, notably France, Austria, and the United States.

The Metallurgy of Welding.

GROUP 3.

Although welding has been in commercial use for more than two decades, only in recent years has it been given the serious attention of metallurgists and this group, presented by Dr. T. Swinden, gives a survey of accumulated experience of problems directly associated with metallurgical aspects of welding. Quite apart from the welding processes employed, it is becoming increasingly recognised that the quality of steel in the welding rod and the quality of steel to be welded have an important influence on the weld, and the properties and characteristics of the metal at and about the weld. This group, which comprises about thirty papers, will be critically examined with a view to a better understanding of problems encountered in welding and their solutions.

A brief survey of the metallurgy of weld rod steel with reference to mild steel or low alloyed steel electrodes is given in a paper by Dr. T. Swinden, while Dr. W. H. Hatfield discusses special steels, since the welding of these steels raise a number of problems quite distinct from those connected with the welding of ordinary steels. In many alloy steels the only safe procedure is to ensure that the analysis of the weld deposit is identical with that of the parent metal in order to have a reasonable reproduction of the desired properties. This applies particularly to corrosion-, acid-, and heat-resisting steels. In addition to the importance of retaining the desired intrinsic corrosion resistance in the deposit, the contact of metals of different composition can lead, in the presence of certain corroding media, to localised corrosion effects, due to electrolytic action. Dr. Hatfield also discusses the influence of the various alloying elements which enter into the composition of special steels in relation to welding properties. The welding of the high-chromium-iron alloys used for heat and corrosion resistance purposes is discussed at some length by Mr. E. E. Thum, of the United States.

Metallurgical fundamentals of high-speed, high-quality autogenous welding are discussed by Mr. A. B. Kinzel, of the United States, in which reference is made to three fundamental requirements for any type of weld: First, mechanical homogeneity of the joint, frequently termed "complete fusion"; second, resulting deposited metal and adjacent base metal of high strength and ductility; third, freedom from internal stress of a high order of magnitude in the finished welded assembly; and he proceeds to analyse and discuss these requirements in so far as autogenous welding is concerned. Several papers are concerned more particularly with welding rods, others with the study of welds, while Messrs. C. G. Bainbridge and E. J. Clarke consider the technical and metallurgical aspects of flame-cutting.

Specification, Inspection, Testing and Safety Aspects of Welding.

GROUP 4.

In any new and progressive industry which includes a number of different processes the question of standardisation generally arises. It is essential as a guide to those who are engaged in the development of that industry to ensure uniformity and co-ordination in the activities, and also to those who wish to adopt a particular process. It is natural, therefore, that, in this group presented by Dr. H. J. Gough, standardisation should have its place, and it is interesting to examine, as Mr. J. O. Cooke has done, how far it is proving of service to the welding industry. This paper reviews the work of the British Standards Institution on welding.

In order to secure organised and reasonable progress along sound lines, it is necessary to carry out the inspection and testing of welding work in such a way as to provide for the utmost safety. Before specifications for welding can be prepared, however, it is necessary to devise standard tests and methods of testing. The existence of the human element in welded work is frequently emphasised, and rightly so, because it increases the necessity for some method of testing to ensure that those engaged in the work are competent and efficient. There would appear to be differences of opinion as to the nature of tests to be applied to electrodes and filler metal, but whatever these may be there is general agreement as to the necessity of some recognised comparative method of testing which can be used as a basis for assessing quality.

Courtesy of Ashmore, Benson, Pease & Co., Ltd.

Welded pipework and vessels for chemical plant.

About twenty-five papers are included in this group, completing a very comprehensive discussion on a subject which has made rapid progress in recent years. This Symposium is much too comprehensive to give other than a very sketchy review here, but bound volumes containing the entire proceedings, including all papers, discussed, and report of the Committee will be prepared as soon as possible, and will be on sale at 30s. per set of two volumes. All interested in the subject are advised to order these bound volumes without delay. Orders should be sent to the Secretary, the Iron and Steel Institute, 28, Victoria Street, London, S.W. 1.

Standards on Refractory Materials.

IN addition to twenty-one specifications, test methods and definitions standardised by the A.S.T.M. on Refractories, this publication includes the "Manual on Interpretation of Refractory Test Data," detailed information on the standard samples of type refractory materials, and reports of extensive industrial surveys, showing the service conditions of refractories in outstanding consuming industries. The specifications cover clay firebrick for various uses, refractories for the construction of incinerators, ground fireclay, and quicklime and hydrated lime for the manufacture of silica brick. Included in the standard methods of testing are: Porosity and volume change; particle size of ground materials; panel test for resistance fo thermal and structural spalling; permanent linear change; test under load at high temperature; softening point; high-temperature heat insulation and chemical analysis of refractory materials.

To help to maintain accuracy in the chemical methods of analysis, a series of standard samples of type refractory materials has been developed in co-operation with the National Bureau of Standards, and a large number of laboratories. The composition of these samples is given in tabular form. It has been essential to have adequate information on the conditions under which refractories are used in manufacturing processes. Comprehensive surveys have been made of such conditions in outstanding consuming industries, including the following: Open-hearth practice, malleable iron industry, copper industry, lead industry, by-product coke-ovens. These reports should be of much interest to those concerned with refractory materials.

Copies of this publication, comprising 143 pages, in heavy paper cover, can be obtained from A.S.T.M. Headquarters, 260 S. Broad Street, Philadelphia, at $1.00 per copy. Special prices are in effect on orders for ten or more copies.

Canadian Radium Industry Now Firmly Established

Despite many handicaps the way is now cleared for progressive expansion.

REVIEWING its operations for 1934, Eldorado Gold Mines, Ltd., Canada's pioneer producer of radium and uranium, reports unusually satisfactory progress in all departments, states a communication from the Department of Mines, Ottawa. With the mine at Great Bear Lake, in the sub-Arctic section of the North-West Territories, and the refinery at Port Hope, Ontario, entailing shipment of ore a distance of nearly 4,000 miles, the enterprise has had a complex situation to overcome. Along with the difficulties and hazards entailed in the transport of men, machinery, and equipment to the Far North, there has been the task of placing into successful operation a chemical refinery, demanding skilled technique in every detail of plant practice. With the many handicaps involved, progress has been necessarily slow in the initial stages, but the past year saw most of the ground work completed with the various technical difficulties solved, and the way cleared for progressive expansion. One of the principal achievements during the year, and one vital for success, has been the perfecting of marketing arrangements for the radium produced. Doubt was not lacking that this could be achieved in the face of the strongly-entrenched Belgian position, but the company reports that it has succeeded in establishing a sales organisation entirely adequate to handle all prospective output.

In its northern operations, Eldorado has entered into a co-operative arrangement with other mining companies in the field for providing adequate transportation facilities to and from the district, and this difficulty is now believed to have been satisfactorily solved. During the year, 750 tons of freight were shipped to the property, including the necessary machinery to increase the concentrator capacity to 75 tons of ore daily. Underground mine development was continued in 1934 with the object of proving the extension, and the downward persistence of the rich ore bodies exposed at the surface. A winze sunk from the drift off the main adit has reached a depth of 250 ft. below the adit level, which in turn is some 90 ft. below the outcrop of the vein, on the hillside. Very encouraging results have attended drifting on the first and second, or 125-ft. and 250-ft. levels, which commenced at the close of the year, and the company, as a consequence, feels justified to proceed with plans for expanding its refinery operations, whereby the present capacity of half a ton of ore daily will be doubled.

Due to the late break-up last year, which seriously delayed transportation, it was near the close of navigation before a supply of ore for the Port Hope refinery could be shipped from the property. Shipments comprising both high-grade crude ore and concentrates totalled 83 tons for the year. To avoid any further delays in ore shipment, and to ensure an adequate supply for the refinery, the company has recently acquired a large freight airplane, which will be used to transport mill concentrates to the railhead at Waterways, Alberta, during the winter months.

The company reports a total production of 6·1 grms. of radium to the end of 1934. This was extracted from 61 tons of ore, giving an average content of 1 grm. to 10 tons. Henceforth, with the production of high-grade concentrates at the mine, the grade shipped will, it is expected, be considerably enhanced. The production of uranium salts is an important part of the refinery operations, and the company reports a ready market for the output. Production to date of such compounds, chiefly orange and yellow sodium uranate, and black oxide, has totalled 60,000 lb. In addition, much of the ore is rich in silver, of which a total of 30,500 oz. has been recovered as a by-product of refinery operations.

Tin Consumption Analysis

ACCORDING to the April issue of the *Bulletin* of the International Tin Research and Development Council, published by the Hague Statistical Office, world consumption of tin in manufacture for the year ended February 28, 1935, amounted to 130,200 tons, compared with 137,300 tons for the previous year. The following table shows the consumption of those countries which used more than 5,000 tons in the period under review :—

	Year Ended February. 1935. Tons.	1934. Tons.	Increase over 1934, %.
U.S.A.	45,795	57,971	— 21·0
United Kingdom	20,890	20,481	+ 2·0
Germany	9,932	10,417	— 4·7
France	8,853	9,954	— 11·1
U.S.S.R.	6,278	3,815	+ 64·6
Other countries	28,047	24,936	+ 12·5
"Apparent" world consumption	119,795	127,574	— 6·1
World consumption in manufacture (approx.)	130,200	137,300	— 5·2
Approx. depletion of consumers' stocks	10,400	9,700	—

The consumption of 6,278 tons of tin in Russia during the year ended February, 1935, is the highest recorded for that country, and represents an increase of 2,463 tons or 64·6% over the previous twelve months. Considerable increases are shown also in the following countries: Canada, 47·0%; Japan, 28·9%; Denmark, 27·8%; Poland, 18·4%; Sweden, 16·0%; Norway, 11·9%. Decreases of 21·0%, 11·1%, and 4·7% respectively are recorded for the U.S.A., France and Germany.

Consumption in Recent Months.

The world's "apparent" consumption of tin during February, 1935, was 10,063 tons, compared with 9,751 tons in the previous month and with 9,146 tons in February, 1934. The apparent consumption in the United States in February, 1935, was 4,071 tons, against 3,024 tons in February, 1934; in the United Kingdom, 1,846 tons, against 1,979 tons; and in other countries, 4,146 tons, against 4,143 tons.

In the first two months of 1935 the approximate world consumption of tin in tinplate was 8,300 tons, compared with 6,700 tons in the corresponding period of 1934, and the quantities of tin used in the automobile industry in the same two periods were 2,550 tons and 1,780 tons respectively.

Indices of Metal Prices.

A new section introduced in this month's issue of the *Statistical Bulletin* contains tables showing the relationship between the prices of various metals. The figures are expressed as indices on the basis of 1913 = 100, and the prices of gold are included, affording a measure of the changes in the value of money. Sterling and gold prices in London and dollar and gold prices in New York are tabulated separately, the figures being given annually since 1925, and monthly since January, 1934.

The following figures selected from these tables show the price of tin compared with five other metals :—

London Sterling Prices, 1913 = 100.

	1929.	1931.	1934.	March, 1935.
Gold	100·0	109·0	162·1	172·8
Copper	110·5	56·3	44·4	41·8
Aluminium	113·6	106·2	119·6	119·6
Nickel	101·8	108·8	125·2	119·1
Tinplate	134·2	102·7	124·9	136·3
Tin	101·1	58·8	114·2	107·1

[A number of articles, prepared for this issue, have unavoidably been held over and will be published next month.—ED.]

Nickel and Nickel Alloy Manufacture

The largest manufacturers of nickel and nickel alloys in the British Empire, Henry Wiggin and Co., Ltd., celebrate their centenary, and this article describes the progress in manufacture and application of their products.

IT can be said with confidence that the nickel industry in this country has had an increasingly important influence on the development of several other industries over a long period of time. Originally used, more or less, for ornamental purposes, nickel has for many years steadily increased its engineering applications. It is only in rare instances that the history of an industry is wrapped up in the fortunes of one firm, but so it is with Henry Wiggin and Co., a firm which is now one hundred years old and whose centenary celebrations have aroused great interest.

It is of interest that the founder of the firm, Charles Askin, obtained his first raw material, nickel speiss residue, from the Potteries, although he was soon faced with a shortage. It was the accidental discovery of what was then a new commercial method of providing refined nickel of high quality that was the real beginning of the firm.

The late Sir Henry Wiggin was the builder of the business to big dimensions, afterwards Mr. Alfred S. Johnston. In 1888 the company bought a red lead business at Smethwick, and while they continued to manufacture red lead they, in addition, erected cupola and reverberatory furnaces for smelting nickel and cobalt ore. Some years afterwards, when the demand arose, tin oxide was also made here, the plant being operated entirely by German workmen. Between 1890 and 1900, part of the land and buildings at Smethwick was loaned to Dr. Ludwig Mond, the inventor of the Mond process of nickel refining, and the first carbonyl nickel to be produced on an industrial scale came from this model plant.

The year 1906 saw the beginning of a new important trade, the manufacture of electrical resistance alloys. "Ferry," a nickel-copper alloy, was followed closely by one of the nickel-chromium-iron series called "Chronic." It is learned with interest that the firm has now one of the best equipped nickel alloy mills in Europe, and probably the world. A great variety of work is undertaken in connection with the production of finished and semi-finished manufactures in nickel and its alloys, of which the production of nickel anodes, electrical resistance alloys, and spoon and fork blanks are amongst the most important. The resistance materials manufactured are the nickel-chromium alloy Brightray, the nickel-chromium-iron alloy Glowray, the nickel-iron alloy Dullray, and the copper-nickel alloy Ferry.

During the last three or four years very considerable developments have taken place at the works of the company and much new plant has been installed.

The Rod Mill and Wire Mills.

From the fettling shop the bars are passed to be hot-rolled to size and coiled for the wire department. Depolarised anodes are also produced in this department, the metal being rolled to oval section, cut to length, and finally drilled and tapped to receive the nickel hooks by which the anodes are suspended.

From the rod mill the rods pass to the heavy wire mill, and thence, if required, to the light wire mill. In the heavy wire mill the metal travels at high speed through the dies. The process varies a little according to the metal being handled, and alloys being the easiest and consequently the quickest to draw. The alloys (which have one complete side of the mill devoted to them) being hard, are not so easy, and repeated annealing is necessary. The annealing of pure nickel, Monel metal, and copper-nickel (Ferry) is carried out in a rather unusual type of furnace—the B.E.F. The coils are placed in the furnace, the temperature of which varies according to the metal with which it is loaded, and after the required time has elapsed a carrier is lowered

The main mill at Wiggin Street works. On the two mills in the centre foreground billets are reduced to strip and sheet.

into a pit of water containing 3% alcohol, which acts as a cleaning agent. The load is automatically lowered into the solution, quenched and brought to the surface again. Nickel-chromium wire rod is "open-annealed" and pickled prior to coating with a special alloy, which facilitates subsequent drawing.

New machines which have been put down in the wire-mill department include continuous wire strand bright-annealing furnaces, which are responsible for the bright finish of the firm's electrical resistance products, the special metallic-coating plant for wire, and the Hesse and Jager and Kratos continuous wire-drawing machines.

With regard to the cold-rolling mill, it receives much of its material, of course, from the hot-rolling mill, but there are those alloys, mainly nickel silvers, which are entirely cold-rolled from the ingot stage. The heavy breaking-down or "getting-ready" mills are the first to handle the heavy hot-rolled sheets, after which they are annealed. The electrical annealing furnaces are located in one corner of the mill.

Of considerable technical and practical interest is the annealing shop, where are the butane atmosphere bright-annealing furnaces for Monel metal and nickel sheets. These electrical furnaces have only recently been laid down, and have resulted in a greatly improved finish on the sheet products. The butane is supplied from cylinders which are

The hot rolling mill at Wiggin Street works is one of the largest non-ferrous mills in Europe.

housed in racks against the wall. The gas, when let into the furnace, prevents the sheets from oxidising. The sheets themselves are carried through the furnace on an endless woven belt of a nickel-chromium-iron (Glowray). An inspection of the entry end of the furnace reveals a most interesting method of keeping the gas within the furnace. Monel chains hung from two horizontal rods, something after the fashion of a bead screen, prove sufficient to prevent any extensive leakage. Both the annealing (muffle) and the butane furnaces were made by Birmingham Electric Furnaces, Ltd.

The Pickling Shop.

The pickling shop affords another instance of the resistance to attack by acids of the 80–20 nickel-chromium alloy, Brightray. The Taylor pickling machine crates installed here are constructed of this metal, and were first installed over two years ago, since when it has been used daily and has handled about 30 tons of material each week. An inspection of the crates and baskets reveals that even the oxide coating has not yet been attacked, and the whole installation appears likely to last for an indefinite period. For general purposes straight sulphuric acid is used, but for the pickling of Monel metal, where complete scale removal is required, a mixture of sulphuric acid and sodium nitrate is used. In recent years manufacturers in many industries have sunk bore-holes to obtain a plentiful and cheap supply of water, and the artesian well is not the least interesting part of Messrs. Wiggin's works.

Most of the nickel-silver ingots are cast in water-cooled moulds, and water is used for the cooling of arc furnace electrode holders, rolling mill bearings, the cooling chambers of the bright-annealing furnaces, the rinsing of pickled sheets, etc. In 1931 22,710,510 gals. of water were used, but in 1934 the demand rose to 45,764,000 gals.; the artesian well, which has just been completed should, therefore, effect considerable economies in production expenses. The well has a depth of 503 ft. and a diameter of 12 in. It is capable of delivering 15,000 gals. per hour from a depth of 160 ft. to 75 ft. above the ground. The pressed steel sectional tank at the top of the tower has a capacity of 18,000 gals.

The main melting department is equipped with two Heroult electric "arc" furnaces and one Ajax-Northrup high-frequency induction furnace. Nickel-chromium alloys are melted in the high-frequency furnace and the charge consists of high purity Mond nickel pellets and high-grade low-carbon chromium. Nickel-chromium-iron, nickel-iron, and nickel-copper alloys are also melted in the high-frequency furnace. The 1½-ton and 10-cwt. Heroult furnaces are used for melting electro-nickel and scrap up to one-third charge in the production of depolarised nickel anodes, nickel for sheet and strip, etc.

Anode casting is done in a special building. Here a 10-cwt. Heroult furnace is installed with casting pit, a type which was one of the first electrical furnaces to be installed in this country. After casting, the anodes have the edges trimmed on a carborundum wheel, the holes are drilled for the hooks, and the casting is then sand-blasted. Any sizes between 1 lb. and 2 cwt. can be produced in this shop.

The laboratories are of primary importance in connection with all metallurgical works, and scientific control is naturally considered of great importance. It is probably because of the attention that Henry Wiggin and Co. have given to these matters that their one hundred years of success is due. The firm appear to become more enterprising and prosperous with age.

Development in Manufacture of Seamless Tubes.

(*Continued from page* 28.)

or drawing processes. It is also claimed that where a solid billet has yielded shell with eccentric walls, this defect – the bane of tube manufacturers –is corrected by the kneading effect hitherto referred to. The state of perfection attained is due to the metal being operated on at a very high speed at a metallurgically correct temperature during which every phase is mechanically controlled and by which any desired length can be produced. A brief summary of the principle features of this new development in high speed mills is that the pierced hollow shell is hot rolled on a long bar in a continuous close coupled rolling mill in preference to being drawn or forced over a stationary plug in the generally accepted two high mill with grooved rolls. By the use of various diameters of bars or mandrels, varying thicknesses of tube may be produced at will, while the changing of the whole mill is a matter of comparative simplicity.

In a set of mills recently constructed, 21 stands in all were embodied, and reductions after completion of operations in the actual mill may be continued in further sets of duo or quarto reducing and sizing mills to any desired diameter and gauge. A large manufacturing concern in the Midlands have completed negotiations for sole use of the invention in Great Britain.

The Diescher Rolling Mill.

A ground general arrangement of the plant of the recently developed Diescher process is shown in Fig. 8; this is available through the courtesy of Messrs. Krupps. The whole arrangement presents a compact and up-to-date installation, one of which is in operation in the Midland district, it being applied to the production of steel tubes. It has not yet been adopted by the non-ferrous tube manufacturers of this country, but the author has evidence that satisfactory results are being obtained on alloys in the United States, and that it has been under observation of British non-ferrous tube manufacturers.

Aluminium Bronze : Its Properties and Applications

The use of aluminium bronze has increased during recent years : difficulties formerly experienced with this alloy have been largely overcome, and to-day the casting and working of this valuable material are being handled in regular commercial production. In this article brief reference is made to its mechanical and corrosion resistance properties, a comparison between casting and hot working the alloy, and some of its applications.

THE bulk of the commercial aluminium bronzes contain 5 to 11% aluminium. Diverse compositions, either in the simple binary or more complex alloys, combine remarkably good mechanical and physical properties with excellent resistance to corrosion by many media.

Although favoured in the early days of their application because of their high strength, the aluminium bronzes have attracted interest in more recent years because of their resistance to corrosion, especially to attack by sulphuric acid, sea-water, and other corrosive media. That aluminium bronzes were resistant to corrosion by sundry media was known prior to 1900, but various applications were out of the question, either because of cost or of difficulty in manufacture. Troubles in the production of castings restricted the application of aluminium bronze for many years. During the last few years, however, the use of aluminium bronze has increased to a considerable degree, and to-day the casting and working of this alloy are being handled in regular commercial production.

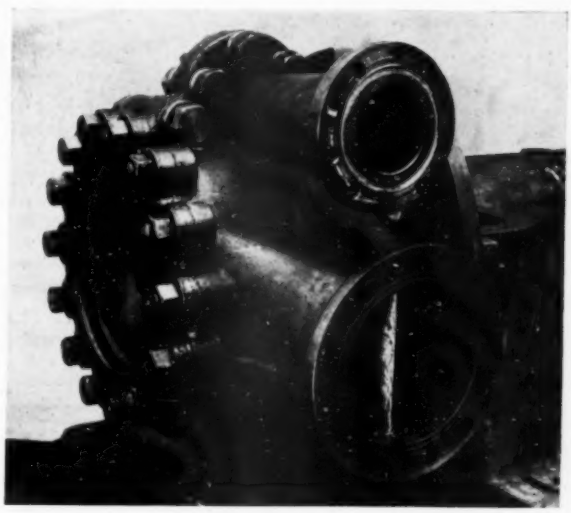
Certain compositions of aluminium bronze are susceptible to heat-treatment—*i.e.*, the mechanical properties may be substantially enhanced by heating to suitable temperatures, followed by quenching or by quenching and annealing.

Most aluminium bronzes used for the production of sand castings, or permanent-mould castings, have been derived from modification in the composition of the 90 : 10 copper-aluminium alloy. This alloy is still used for castings, but most aluminium bronzes employed to-day are more complex. The composition of the 90 : 10 copper-aluminium alloy is altered by the addition of other elements to enhance the mechanical properties ; improve the resistance to certain corrosive media ; improve the casting or working qualities ; and increase or reduce the susceptibility to heat-treatment. Solid-solution binary copper-aluminium alloys, containing 5 to 8% aluminium, are used for some wrought products, but seldom for castings ; these alloys may contain small percentages of iron, manganese, or nickel.

While the mechanical properties of the aluminium bronzes cannot be dealt with in detail here, a few figures may be given to indicate the values obtained. The 90 : 10 copper-aluminium alloy as sand-cast has the following properties :—Tensile strength, 32 tons per sq. in. ; yield-point, 11 tons elongation in a 2-in. length of 22% ; and Brinell hardness, 95. When sand-cast and heat-treated, the properties of this alloy are :—Tensile strength, 41 tons ; yield-point, 22 tons ; elongation, 8% ; and Brinell hardness, 175. The 89 : 10 : 1 copper-aluminium iron alloy, as sand-cast, has the following properties :—Tensile strength, 33 tons ; yield-point, 12 tons ; elongation, 24% ; and Brinell hardness, 95. The 88 : 9 : 3 copper-aluminium-iron alloy, as sand-cast, has the following properties :—Tensile strength, 34 tons ; yield-point, 24 tons ; elongation, 44% ; and Brinell hardness, 110.

Aluminium bronze alloys frequently contain above 10% iron, 5% manganese, and 5% nickel, while nickel up to 3 or 5% is used for marine propellers. Small percentages of manganese raise both the tensile strength and permanent-set limit without impairing the ductility.

Worked aluminium-bronzes are produced with tensile strengths in excess of 50 tons per sq. in., and elongation of around 10 to 25%. The aluminium bronzes have excellent resistance to alternating fatigue and high compressive strength. Alloys of suitable compositions may be heat-treated to yield a considerable range of mechanical properties—*e.g.*, very high elongation, or some combination between the two. Heat-treatment may consist either of quenching from suitable temperatures or of quenching



Marine valve in aluminium bronze for high-velocity service.

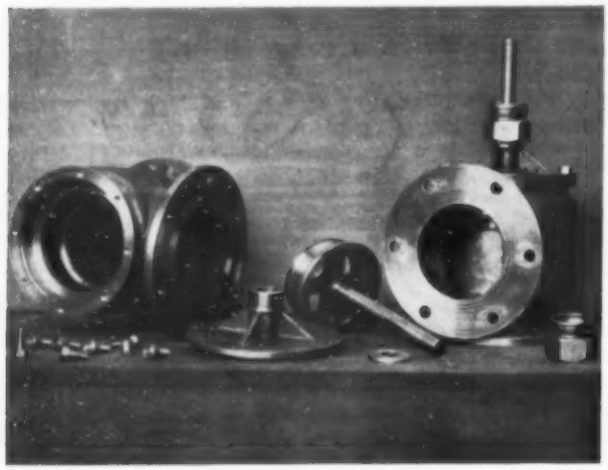
followed by annealing (reheating at a temperature considerably lower than the quenching temperature). The properties obtained depend upon the temperature of quenching and the time and temperature of annealing. For the 90–10 copper-aluminium alloy or some usual modification thereof, typical treatment consists in soaking at 900° C., followed by quenching, and then drawing at 400° to 700° C.—the drawing temperature selected depending upon the properties desired.

Methods of casting and working, heat-treatment, resistance to corrosion, mechanical properties, metallography, and applications, as applied to the aluminium bronzes, have been treated at length in many published papers, and a large literature has been built up on the whole subject. Almost invariably, emphasis is laid on the need for particular care in the foundry in dealing with these alloys ; and a rational conception of design is required if the fullest advantage is to be derived from their special qualities.

Most Useful Range of Alloys.

Probably the most useful range of the aluminium bronze alloys fall within the α and β range ; these when in perfect general condition give maximum mechanical characteristics, ranging from 38 to 41 tons per sq. in. ultimate stress in sand castings to 51 tons in chilled castings and forgings. This high tensile strength enables a reduction in weight to be obtained in castings and forgings usually made in other metals ; an important factor, which has an appreciable effect in reducing the cost of parts made in aluminium

bronze. Meigh* described principles by which he had realised a reduction in weight of 40 to 60% on such parts as marine stop-valves, plug cocks, full-way slide valves, etc., which had previously been made in the 88–12 copper-tin alloy, while the factor of safety was either unchanged or increased. A result which seems to indicate that the weight of many parts can be reduced by the use of high-tensile non-corrodible alloys with more security than by the use of light alloys which are more or less corrodible.



Steam-reducing valve in aluminium bronze.

It should be pointed out, however, that the best results from aluminium bronze can only be obtained by the close collaboration of the user, the designer, and the foundryman, and the experience acquired on previous work allows a continual extension to be made in the range of applications of the metal.

Hot Working.

It is further pointed out by Meigh that, in the majority of cases, parts cast in aluminium bronze are sounder and cheaper than if they were produced by forging, stamping, or by other methods of hot working. Apparently, in contrast with many other metals and alloys, hot working does not improve any characteristic of aluminium-bronze except the elongation, which in the cast state is already satisfactory. In other words, micrographical control will reveal a reduction in grain size which corresponds to an increase in tensile strength. This is discussed in the paper by Meigh, previously mentioned, who developed the Meigh process,† which is designed to obtain the correct solidification speeds in given zones of a casting in order to develop the best physical and mechanical properties in the wide range of aluminium bronze alloys.

Very high tensile strength is found in light wrought sections, principally caused by a partial quench or the effects of work-hardening at a low temperature, but equal if not superior characteristics, with corresponding microstructures are to be found in similar sections in the cast state. Light sections in chilled castings normally give an ultimate stress of 51 tons to the sq. in., and the minimum given by any section, either sand or chill, is 38 tons. These figures apply to the heart of a block of metal just as well as to the outer surface. On the other hand, in wrought material, and, above all, in heavy sections, a test-piece taken from the heart of a block of metal would not give the same result as one taken from the surface of the same block, and neither the one nor the other would give a result approaching that found if a part of the same block were reduced to 20 mm. diameter, for example.

These three results would bear fairly constant relations to one another as far as similar sections are concerned, but the small 20 mm. bar would give at least a 20% higher ultimate stress than the average of the other results obtained in the heavy sections. The improvement in the small section is either due to a partial quench or to work hardening at a low temperature, or perhaps a combination of both, but the improvement should in no way be attributed to the effect of working at a high temperature.

The transformation points in the different aluminium bronze alloys vary according to the chemical composition of the alloy, but it can be considered that one is situated between 490° and 650° C., and the other between 740° and 906° C. If an alloy is studied, the transformation points of which are at 500° and 800° C., it can be considered that work done at a temperature above 800° C. improves nothing but the elongation, an effect which is characterised micrographically by the lengthening of the α and β elements in the longitudinal section of the work. Between 500° and 800° C. there is a point where work hardening commences, which causes the fragmentation of structure and a corresponding increase in yield-point and ultimate stress. But heavy sections cannot be worked to the heart of the metal at these low temperatures, and the effect of working is more or less superficial, a condition which increases internal stresses in the metal.

The degree of work hardening produced by a given deformation depends on both the speed at which the metal is deformed and on the temperature at which the work is done. The slower the deformation speed, or the higher the temperature at which the deformation occurs, the less the effect of work hardening is visible after a given amount of deformation. Consequently, hot working in aluminium bronze should only be considered as a method of producing sections which cannot easily be cast, such as bars which are long or wide in comparison to their thickness, but when material can be cast its quality is as good if not better than when it is in the wrought state. As already mentioned, aluminium bronze does not weld itself when forged, and the advantages obtained from hot working are negligible.

Some Applications.

There are numerous instances where both mechanical properties and resistance to corrosion are met by the use of aluminium bronze ; in other applications the resistance of corrosion is the primary factor leading to the selection of an alloy of this type. At the present time aluminium bronzes are furnished as sand castings, permanent mould castings, sheet, rods, angles, pipe, tubes, wire forgings, and such fittings as bolts, nuts, rivets, washers, lag-screws, and the like. Many types of castings are produced, and sheet is worked into various shapes by drawing and forming.

One of the most important present uses of aluminium bronze is in the construction of equipment for pickling steel parts in sulphuric acid. Tanks, crates, racks, and baskets, as well as hooks, slings, wire ropes, chain, and various tank fittings are made of this alloy. Some large racks are cast, and crates may be constructed of angles and sheet. Tanks are made of sheets and shapes welded together. Another application is for tank tie-rods in the construction of wooden tanks used for holding sulphuric or hydrochloric acid. Aluminium-bronze bolts and screws are also employed in such tanks. Equipment for the chemical industry, including pumps, stills, valves, autoclaves, and piping, is made of this alloy. Thus, pumps made entirely of aluminium bronze are used for the handling of sulphuric acid, particularly in pickling operations. In passing, it may be pointed out that it is of advantage to construct equipment exposed to corrosive influences entirely of the same material, thereby avoiding the severe electrolytic corrosion that occurs when two different metals are in contact. Pumps are made of castings and forgings of aluminium bronze bolted together with bolts of the same alloy. Reciprocating, rotary, and centrifugal pumps are made of aluminium bronze. In some pumps the rods, valve-plates, and liners are made of aluminium bronze. Flanged and screwed

* Meigh. Paper entitled "Rational Use of Aluminium Bronze by taking into consideration Solidification, Hot-working, and Internal Stresses," delivered before International Foundry Congress, September, 1932.

† The rights for working the Meigh process in the British Empire are controlled by T. M. Birkett and Sons, Ltd., Hanley, Staffs.

valves are made in various sizes, particularly for use in acid-conveying systems—*e.g.*, in handling oil-refinery sludge acids.

Another use of aluminium bronze is in the construction of ventilating systems for ducts and fans. Ducts are made of sheet. Exhaust fans are made in standard types. Aluminium-bronze ventilating systems are used in pickling rooms, storage-battery rooms, rubber vulcanising plants, newspaper plants (over linotype melting pots), dry houses, laboratories, and other places for handling corrosive vapours. In cases where steel fans are completely destroyed in a relatively short time, aluminium-bronze fans may last almost indefinitely without painting or otherwise treating. Another application is in the construction of filter presses, for frames and rods—*e.g.*, for use in rayon plants, where weak solutions of sulphuric acid are handled. Owing to its high resistance to corrosion by sea-water, aluminium bronze finds application in marine work for propellers, rudders, and various fittings. One of the earlier applications of aluminium bronze was for valves, fittings, and other parts in the paper industry, where sulphite liquors are handled. Owing to the fact that this alloy tarnishes very slowly in ordinary air and retains its colour well in sea air, it has been used to a considerable extent for making subsidiary coinage.

While the general field of application has been indicated above, many other specific uses of aluminium bronze might be mentioned, and new uses are continually being found.

Metallurgical Researches in U.S.S.R.

TO aid the task of turning the U.S.S.R. into a metal-producing country, the Soviet Academy of Sciences has carried out a series of important works on problems relating to metals. Much work was done in 1934 in the study of ores by Academician A. D. Arkhangelsky, who investigated the chemical composition of iron ores from various deposits in the U.S.S.R. from the point of view of the processes of their formation and the formation of the Ural, Altai, and other bauxite deposits. As is known, bauxite is the best ore for the extraction of aluminium. The work of Academician Arkhangelsky has had the result of extending the base of supply of the raw material and of improving the methods of utilisation of the useful component parts of ores.

In the Lomonosov Institute of the Academy of Sciences research has been completed on the deposits of Ural titano-magnetites, which are of tremendous value as a source of iron and titanium. The results of this research have been published in the form of a large monograph.

Side by side with the foregoing researches of the geological section of the Academy of Sciences, the technical section carried out considerable research in the field of metallurgy. The most important work here was done by Academician M. A. Pavlov on the theory and practice of blast-furnace smelting. Pavlov performed experiments in the use of peat for smelting iron in blast-furnaces, as a result of which he has drawn the conclusion that the use of peat in small blast-furnaces is quite practicable. This finding is of great significance for regions containing iron ore but no coking coal.

Increasing the capacities of blast-furnaces is at the present time one of the most important tasks of Soviet metallurgy. The Magnitogorsk furnaces, with an output of 1,000 tons of pig iron a day, are the first experiments in the U.S.S.R. in the construction and exploitation of furnaces with such a large capacity. Academician Pavlov made two visits to Magnitogorsk in 1934 to take charge of the study of the work of this plant being carried out by a group of scientific workers from the Central Institute of Metals.

Though the Magnitogorsk blast-furnaces are very huge, their dimensions are not the largest possible. The State Institute for the Protection of Metallurgical Plants is now engaged in designing a super-powerful blast-furnace, considerably exceeding those of Magnitogorsk in productivity. Academician Pavlov is taking an active part in this work.

Steel Rail Production.

Chrome, chrome-nickel, and manganese steel are broadly applied in machine building and other branches of heavy industry. Hence, the theoretical investigation of the alloys of iron with manganese, chromium and nickel is of great importance. A systematic investigation of these alloys is being made in the Institute of General and Inorganic Chemistry of the Academy of Sciences under the direction of Academician N. S. Kurnakov. In the same Institute extensive research work is being done on light alloys, so necessary for the aviation industry, and the alloys of non-ferrous and ferrous metals.

In the field of working metals, particularly noteworthy are the works of Academician I. V. Grebenshchikov, who has established that the process of polishing is not merely a mechanical process, but a chemical process as well. By introducing into the composition of the polishing material chemical reagents acting on the surface of the metal being polished, it is possible considerably to speed up polishing. Academician Grenenshchikov has proposed and put into effect new methods of polishing metals and new abrasive materials.

The problem of metals has still another important side—protection from corrosion. The theory of corrosion and methods of combating it have also received the attention of the Academy of Sciences. Academician V. A. Kistiakovsky and his pupils have achieved considerable success in this field.

The New Orsk-Khalilovo Combine.

Work on one of the biggest industrial combines in the U.S.S.R. has commenced, in the Orsk-Khalilovo District in the Urals, which will be of far-reaching importance in the industrialisation of the Soviet East. This district contains very high bearing deposits of iron ore and nickel, which, according to preliminary estimates, amount to 95 million tons. Large quantities of iron ore are also to be found at the Novo-Akerman District of the same territory, and in the vicinity of the Novo-Orsk railway station.

Great importance is attached to the copper deposits found at Blyava, which are estimated to contain about 400,000 tons of copper. Large deposits of nickel have also been located in Akkerman, Kamlers, and Aiderla, all in the same neighbourhood. Deposits of manganese ore, refractory material, coal and other minerals have also been found in the vicinity, creating an excellent base for the establishment of a building materials industry.

It is on the basis of this natural wealth that the construction of an industrial combine has been decided upon in the Orsk-Khalilovo District. Of first importance in the combine will be the iron and steel works in Khalilovo. It is estimated that the capacity of the iron and steel plants will be about one million tons of pig iron and a similar amount of steel. The nickel available in the district will be used in the manufacture of alloy pig iron and superior quality steel for the machine-building industry.

In conjunction with the metallurgical works, a chemical coke plant will be built and exploitation of the coal deposits will be organised. The combine will also include a copper plant and a nickel plant, the latter one of the largest in the world. In addition, an oil refinery will be built with an annual capacity of 1·5 million tons of crude oil, two central electric heating stations with a combined capacity of 300,000 k.w., and a plant for the manufacture of large locomotives. The latter is already under construction; part of it is to be put into operation in 1937, and the remaining part in 1938.

The Case against "Self-Government" in Industry.

IN an address on the above subject at the annual dinner of the Chemical Engineering Group of the Society of Chemical Industry, Lt.-Col. Sir Arnold Wilson, M.P., severely criticised the Government's policy in relation to agriculture and other matters. In referring to the electricity grid, which, he said, had been completed at vast cost "by virtue of the legislative authority of Government," he knew of no one who was prepared to state with certainty what, if any, economies had resulted or would result in the near future, comparable with the cost. The scheme was based on the assumption that generating costs were all-important, and costs of distribution were secondary. The scheme might or might not be good, but Sir Arnold was not satisfied that it would of itself help to reduce the costs of electric power, or that private enterprise, given freedom from the dead hand of antiquated legislation of the past, would not have put the same capital expenditure to better uses. His contention is that the business of a government in a civilised country is not to engage itself, officially or by deputy, in the complexities of production and distribution of perishable commodities. Its primary function is to establish conditions in which private persons can undertake such tasks to mutual advantage in service of the consumer. Consumption cannot be planned, though more might be done by the central Government, on whose bounty local governments increasingly depend, by stipulation that those who are fed at the cost of the State in the Services and in the institutions should be fed with local produce, and not, as at present, so as to save trouble to the staff, mainly with foreign produce.

The all-important factor in consumption is price. If bricks go up, men turn to cement. If steel rises above a certain point, reinforced concrete is substituted, and so on without end. There is almost no limit to substitutes, as we shall presently learn, to our cost, from the example of Germany. Goods must find their own market at their own price unless there is a real or artificial shortage, or unless, alternatively, consumption is controlled as well as production and distribution.

Every officially sponsored scheme involves discrimination between rival industries and a demand for compensatory consideration in a second scheme from the interest adversely affected by the first. The gospel of planned national economy presumed, contrary to all experience, that the immense and continuous process of automatic adjustment of the industrial machine to new processes, new markets, new tastes, could be effectively supplied by the plans of autonomous boards and government departments. The lobbying of successive groups of industries for assistance is bound to provoke suspicion and, later, indignation, while all the time private enterprise is responsible for finding the money for the very policy which is designed to restrict and perhaps ultimately to abolish its own activities. If the Government's policy is to be one of continuous interference with industry it must be accompanied by the assumption of public responsibility for the control of industry. People will not lose their liberty without unloading their responsibilities.

Sir Arnold did not question the need for planning, or for reorganisation, but claimed that to succeed it must be voluntary and not imposed from above. He does not doubt the need for centralised selling; it has sometimes, but not always, succeeded; but once it becomes compulsory it becomes rigid, a new vested interest arises. Those of us who have had some experience of industry know that, as Mr. W. Runciman said recently, "a useful invention is worth more than seventy Acts of Parliament." How would such inventions be received by a fully organised industry? We are trying to do more governing and more controlling than any nation can undertake with success. In doing so we are in danger of wasting our greatest asset—the independence of character which is the product of real responsibility. Is the extra "efficiency" worth obtaining as the cost of character and self-reliance? Is the status and security of a paid man who may lose his job in the biggest firm when times are hard so much better than the status of the independent shop-keeper, who still gets business because he studies his customers and they trust him?

The great choice lies before us. No nation stands still. It must move in one direction or the other. Either the State must grow in power, imposing new burdens and compulsions, and the nation sink lower and lower into a helpless quarrelling crowd, or the individual must gain his own rightful freedom . . . determined to end this profitless and worn-out system of restrictions and compulsions, which is not good or healthy even for children.

Lubrication in Working Aluminium.

IN working aluminium, both with and without cutting tools, lubricating oils are used for the purpose of facilitating the working process, preserving the tools, and improving the surface finish and accuracy to size of the product. Because of the high working temperatures used in rolling aluminium the oil which is applied to the roll barrel must be of a high viscosity. A further requirement is that the oil burns without leaving a residue, otherwise stains are formed on the sheet. The high-viscosity oil can only be used in rolling sheets down to a thickness of about 0·1 in. In further reducing the sheet thickness a more thinly liquid oil must be applied which distributes more evenly over the roll body. In rolling foil further diluting media are added to the oil, such as benzine or petroleum, in order to get a uniform foil thickness. As the foil is annealed after rolling the freedom from residue of the oil is of great importance. In order to save money it is advisable to apply the oil by a mechanical device and not by hand, because in the latter case the supply is, in most cases, too ample and too irregular. Sometimes the interior of the roll is water cooled. In order to protect the roll from corrosion it is favourable to add a corrosion-resisting oil to the cooling water. A quantity of 1% is sufficient. The same oil may also be added to the pressure water of the hydraulic plant.

In extruding bars and pipes, die and mandrel are lubricated with the same oil as used in rolling, in order to prevent scoring and the formation of dark compression marks. When working under very high pressures it is advantageous to add graphite to the oil to the consistence of a thin paste. The ash content of the graphite must be as low as possible because the ash acts like a flux. In pressing and spinning aluminium sheet an oil is used as lubricant which gives a stable emulsion with water. In most cases the mixing ratio is 1 : 10. The lubricant must be chemically inert, and should be applied mechanically, and to the sheet not to the tool, in order to avoid loss by spilling. In drawing aluminium wire it is advisable to use in the last drafts a special vaseline as lubricant, which imparts a bright surface finish to the wire and acts afterwards as a preservative.

In working aluminium with cutting tools, as in turning, drilling, and milling, in most cases an oil is used which gives a stable emulsion with water, the mixing ratio being 1 : 10. It is advisable to control the mixture regularly, because it becomes poorer and poorer in oil. Some aluminium alloys which have been developed in recent times require a special cutting oil, used in the concentrated state. (Extracted from *Aluminium*, Sept., 1934.)

Mr. Roland Dunkerley has resigned his position as Comptroller of The United Steel Companies, Ltd., Sheffield, to take up a position as Director and General Manager of Zuilt Manufacturers, Ltd., Manchester. A well-known figure in business circles, particularly in Northern England, Mr. Dunkerley is a recognised authority on budgetary control and cost accountancy, and his work has been closely identified with the progress made by The United Steel Companies, Ltd. He will take up his new appointment early in June.

The Iron and Steel Institute

Annual General Meeting in London

THE annual meeting of the Iron and Steel Institute was held in London on May 1–3, at the Institution of Civil Engineers. The initial meeting with Mr. W. R. Lysaght, the retiring President, in the chair, was confined to Institute business, towards the conclusion of which the Bessemer Gold Medal was presented to Prof. A. M. Portevin, Director of the Institut de Soudure Autogene, Professor at Ecole Superieure de Fonderie, and at the Ecole Centrale des Arts et Manufactures, Paris. Sir Harold Carpenter, the new President, was installed, and delivered his presidential address on "Alloys: Old and New," in which he reviewed briefly the history of alloys and proceeded to present factors associated with the study and application of alloys to-day.

The Study of Alloys.

The study of an alloy, he stated, would be greatly simplified if it were possible to consider separately each of the factors that constitute its nature in relation to each stage in its treatment and each of its properties; actually, however, nature treatment and properties are so intimately connected that they must be considered together. Thus, although various headings may be selected to facilitate description it is impossible to adhere strictly to this plan.

After a very thoughtful consideration of the subject of alloys, Sir Harold concluded that the composition is the first factor to be considered in connection with the properties of an alloy. All properties depend on this to a greater or less extent, but other factors—constitution, structure, and condition—are also important. The composition is fixed when the alloy is cast, while the other factors are influenced by the casting technique and the heat and mechanical treatment of the solid metal. Most of the alloys used in the cast condition contain an eutectic—*e.g.*, the cast irons, aluminium copper, and aluminium silicon. Bronze contains a eutectoid, while brass consists of solid solutions. Most of the alloys used in the worked condition solidify as solid solutions—*e.g.*, steel, brass, copper-nickel, and the heat-treatable alloys of aluminium. Finally, most of the alloys subjected to heat-treatment solidify as solid solutions and undergo subsequent changes in the solid—*e.g.*, steel and the heat-treatable light alloys.

Heat-treatment consists of controlled heating and cooling operations designed to modify the properties of an alloy by promoting or preventing constitutional and structural changes. But these are also influenced by the presence of elements other than those required, which have to be reckoned with. Steel is the outstanding example of an alloy in which the mechanical properties depend on constitution and structure, and the control of these by heating and cooling and by the addition of other elements.

Technical Sessions.

Technical sessions were held at which several papers were presented in addition to the third report of the Corrosion Committee. These, together with the Welding Symposium, referred to elsewhere in this issue, were responsible for making the meeting one of considerable importance. The papers and report are summarised in the following:—

An Investigation on Spring Steel.

This paper by Prof. J. H. Andrew and Mr. G. T. Richardson gives an account of an investigation of the manufacture of spring steels, from the billet stage to that of the heat-treated plate, carried out with the object of determining the effect of surface decarburisation during the manufacturing process. It is divided into two parts, the first dealing with silico-manganese steels and the second with chromium-vanadium and plain carbon steels. Details of heating for rolling, of rolling, and of the final heat-treatment are given. The important feature emphasised is the decarburised layer resulting from furnace treatment at different periods of the process.

It is shown that heavy scale on the surface of spring plates plays an important part in the efficiency of the quenching operation. Contrary to expectations, a specimen with the greatest depth of decarburisation and only slightly scaled, becomes hardened to a greater degree than one only slightly decarburised, indicating that a layer of ferrite on the surface is instrumental in causing a more thorough quenching than a similar steel surface, possibly on account of the higher conductivity of the free ferrite.

Silico-manganese steel seems to be inferior to plain carbon and chromium-vanadium steels for the following reasons: (*a*) It is always more decarburised than the other two, owing to the scale being more friable and of a less protective nature; (*b*) the steel is very susceptible to mass effect. Once the length of a spring plate exceeds 6 in., the hardnesses at certain positions do not coincide until a temperature of quenching approaching 1,050° C. has been reached; (*c*) the structure of the hardened spring plates is appreciably altered by (1) the temperature reached before rolling begins, and (2) the temperature from which quenching takes place; (*d*) the scale seems very friable, easily breaking off and leaving a rough and jagged surface. Such a surface, along with intercrystalline penetration of oxide, has been shown to be weak; and (*e*) there is always some penetration of oxide in the surface layer and along the grain boundaries, whatever the temperature to which it has been heated.

Chromium-vanadium steel seems to be decidedly superior, as (*a*) under identical conditions it decarburises and scales the least. The scale produced, however, protects the surface, which is not jagged like that of silico-manganese steel; (*b*) penetration of scale along the grain boundaries does not take place; and (*c*) it is not greatly influenced by mass effect, nor does the temperature of quenching seem to influence the final structure. In no case has the structure of quenched specimens been observed to be coarse, as with carbon and silico-manganese steels.

The Deflection of Rolls in Plate, Sheet, and Strip Mills.

The art of the roll manufacturer and the rolling-mill engineer is directed towards the provision of rolls which have a surface profile suitable for accurate rolling under normal working conditions. The working surface is given a camber or concavity which compensates for the slight changes which are produced under working conditions. These conditions arise mainly as a result of temperature variations along the rolls and the deflection of the rolls under the rolling loads.

One of the chief requirements in the rolling of some strip and sheet products is accuracy and uniformity of gauge. The methods of approach to accuracy are described in this paper by Mr. J. Selwyn Caswell, and detailed consideration is given to the deflection of the rolls. The relationship between the rolling loads and the roll deflections is discussed, and the importance of it, when a high degree of accuracy is required, is emphasised.

In the calculation of the approximate roll deflections, consideration is given to the combined effect of the longitudinal flexural stresses and the shear stresses. The limitations of the ordinary bending theory are discussed,

and reference is made to the recent photo-elastic researches on the bending of beams having roll proportions—that is, a small value of the span/depth ratio.

Formulæ are derived for use in calculating the approximate values of the roll deflections at the centre of a roll and at points removed from the middle of the roll. The formulæ are applied in a particular case to illustrate their use and to indicate the order of magnitude of the roll deflections. The results are compared with some interesting mill observations relating to roll deflection, and the need for further experimental observations is urged.

Although this paper is short, sufficient has been indicated to demonstrate the relationship between roll deflection and accuracy in the rolling of flat stock, and also to show the method of obtaining an approximate estimate of the amount of the roll deflection. In view of the uncertainty relating to the magnitude and the distribution of the stresses in the rolls, the author is of the opinion there is need for careful experimental investigation on this matter.

The Resistance of Spring Steels to Repeated Impact Stresses.

The work described in this paper by Dr. G. A. Hankins and Mr. H. R. Mills has been carried out at the Engineering Department of the National Physical Laboratory, as part of the investigation on the effect of surface conditions on the fatigue resistance of steels. The investigation in this instance was carried out to determine whether the irregular decarburised surface which is present on a normal heat-treated spring steel plate affects the resistance to repeated impact stresses.

Single blow and repeated blow impact tests were carried out on three heat-treated spring steels, in the machined and polished and in the as-rolled and heat-treated conditions, using unnotched specimens. Tests were also made on a surface carburised plate and on a steel which had been machined and then heat-treated in such a manner as to minimise surface decarburisation; both these materials possessed high endurance fatigue limits for cyclic stresses. The repeated impact tests were made with a wide range of impact energy, varying from an impact which would break a test-piece in a few hundred blows to one which a test-piece would resist for over one million blows.

For nearly all the materials the results suggest that a repeated impact endurance limit is revealed by tests on a one-million impact endurance basis. In general, the irregular decarburised surface on a spring plate produces a low repeated impact endurance limit (10^6 impacts) in the same manner as it produces a low endurance fatigue limit; the defective surface appears to have no adverse effect, however, on the resistance to a large impact of magnitude approaching the full single blow impact strength of the plate.

Further Determinations of the External Heat Loss of Blast-furnaces.

An earlier investigation of the external heat loss of a blast-furnace[1] suggested that this loss was considerably smaller than had been thought probable, and was mainly in the cooling water used. Further tests have been made to elucidate the factors governing this loss of heat, and this paper by Mr. D. F. Marshall is a record of an experimental determination of the external heat loss from four blast-furnaces, selected to cover a wide range of rate of production, type of product and general practice. The influence on the heat loss of various factors such as the rate of drive, the life of lining, cooling winds, exposed sites, the use of bosh tuyeres, and the water-cooling of shafts, has been investigated and an attempt made to measure their effect on furnace operation, in terms of fuel consumed.

The results indicated that the external heat loss was largely a function of the superficial area of the furnace, and was considerably lower than the estimates previously given. The relationships existing between the heat losses from the furnaces examined did not appear to be materially affected by changes in operation from furnace to furnace, or on one furnace.

The author found that the heat loss per unit surface area of the water-cooled zones (bosh, spectacle belt, and hearth) is very similar on all the furnaces examined, but it does show a tendency to decrease slightly on the larger furnaces. It follows therefore that the total surface area of the water-cooled regions on a furnace is an important factor, governing the total external heat loss from that furnace. One furnace examined incurred additional water-cooling losses in bosh tuyeres and cigar coolers. The results at this plant fell closely in line with those obtained at others, when due allowance was made for the additional heat loss involved by the extra cooling.

There is a very considerable variation in the amounts of cooling water used from plant to plant, even where similar types of cooling are employed. It is possible therefore that considerable economies of both heat and water might be effected by making a systematic examination of the distribution of the heat loss in the cooling water at each furnace.

The heat loss from the shaft of each furnace constitutes a relatively small proportion of the total loss. The cooling effect of strong winds and the influence of exposed furnace sites are therefore correspondingly small factors governing the total heat loss. The experimental results suggest that the value of shaft insulation lies not in the actual reduction of the shaft heat losses, but in the possibility of prolonging the life of the furnace lining. Although the heat loss per unit of shaft area tends to increase as the lining ages, there is some evidence that the rate of drive of a furnace plays a more important part in governing the loss of heat from the shaft.

Non-metallic Inclusions in Ferro-alloys.

This paper by Mr. B. Matuschka, of Austria, deals with the nature and quantity of the non-metallic inclusions in ferro-alloys—a problem of growing importance in view of the steadily increasing use of alloyed and super-alloyed steels. It also affords some guide to the nature of the inclusions which can form anew, under similar conditions, in the alloyed steels. The investigation reported in this instance is confined to the effect of metals as alloying elements, but not as deoxidising agents.

After considering in general terms the structure and the physico-chemical behaviour of the slag inclusions in liquid and solid steel and their effect on the working and use of the finished material, the author deals with the degree of purity of the added ferro-alloys as an important quality factor in the production of high-grade alloy steels. He then investigates the principal commercial alloys for their percentage of non-metallic inclusions, and discusses the nature, occurrence, and behaviour of these inclusions in steel melting.

The Iodine Method for the Determination of Oxides in Steel.

The iodine method for the estimation of oxides in steel may be described as a "residue method." It consists in dissolving a sample of drillings in a solution of iodine, filtering, igniting and weighing the insoluble residue. The ignited residue is examined for silica, oxides of iron, manganese and aluminium, etc. Various modifications of the method have been proposed which differ mainly in the composition of the iodine solution. A method was introduced to the National Physical Laboratory by Dr. C. H. Desch, F.R.S. As a result of the experience gained in the use of the method at the National Physical Laboratory the apparatus and procedure have been somewhat modified. This method and the modified apparatus is described in this paper by Messrs. T. E. Rooney and A. G.

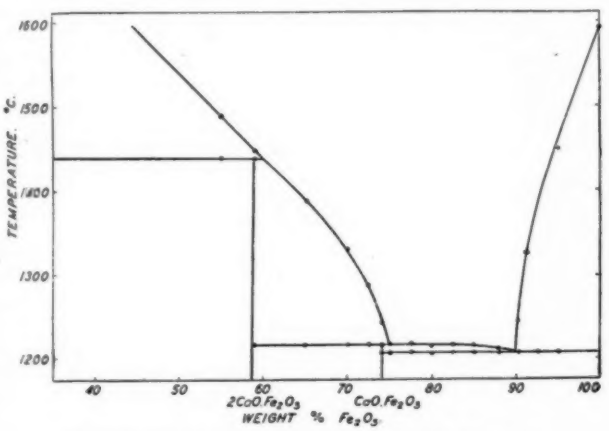
1 D. F. Marshall, "The External Heat Loss of a Blast Furnace," *Journal of the Iron and Steel Institute*, 1933, No. I., p. 127.

Stapleton. Details of the apparatus and the procedure necessary for obtaining correct results are given, and results are shown with two types of filter.

Transformations in Iron-aluminium Alloy

This paper, by Messrs. C. Sykes and H. Evans, describes an investigation of interesting transformations occurring in the solid state in alloys of iron containing from 11 to 17% of aluminium by weight. It is shown that under conditions of slow cooling, atomic rearrangement (" ordering ") occurs in alloys of the approximate composition Fe_3Al. Its effect on the cooling curve, electrical resistance and magnetic properties of this series of alloys has been examined. The heat evolution due to the ordering process starts at about 560° C., and continues over a considerable range of temperature, probably down to about 200°–250° C., depending on the cooling rate. Measurement of the resistivity of samples quenched from various temperatures also enables the critical temperature to be ascertained, and the value so determined is in good agreement with that obtained by purely thermal methods.

The magnetic change points of alloys containing from 11 to 17% of aluminium by weight (Fe_3Al = 13·9% Al) have been determined. It appears that the ordering process can in certain cases affect the magnetisation-temperature curve, so that the magnetic properties are of considerable interest from the academic point of view. From the experiment results described in this paper the authors state it is clear that alloys of approximately the composition Fe_3Al possess many interesting and hitherto unsuspected properties. Whilst the general nature of the transformations has been established, the phenomena observed are extremely complicated, and further experimental work seems desirable in order that a complete explanation may be developed.



Thermal equilibrium diagram of the system CaO—Fe_2O_3.

An Investigation into the Oxidising Power of Basic Slags.

In recent years much attention has been given to the functions of the slag in the refining operations in the open-hearth process of steel making. McCance[2] has recently reviewed the work in this field, and has shown that whilst the behaviour of the slag metal relationships in the acid process can be accounted for in a reasonably satisfactory manner on theoretical grounds, the same cannot be said for the basic process. In the latter process one of the outstanding anomalies is the rapid accumulation of FeO in the finishing slag. In discussing this phenomenon, McCance states that he believes that Fe_2O_3 plays an important part owing to the formation of calcium ferrites. In this paper by Messrs. J. White, R. Graham, and Dr. R. Hay data is collected on the properties of various ferrites, but, in addition, it was felt desirable to redetermine the thermal diagram for the CaO–Fe_2O_3 system, thus the paper is presented in two parts, the first being concerned with the determination of the binary diagram CaO–Fe_2O_3 and the second with the determination of the dissociation pressures of Fe_2O_3, $CaO.Fe_2O_3$ and $2\,CaO.Fe_2O_3$.

In the binary system Fe_2O_3–CaO, evidence of the existence of two compounds only, monocalcium ferrite and dicalcium ferrite, has been obtained. The more important optical properties of these compounds have been ascertained. At the Fe_2O_3 end of the system the diagram is really of a pseudo-binary nature, due to the dissociation of the excess Fe_2O_3 at high temperatures. The melting point of Fe_2O_3 was determined as 1,595° C., but this figure is low, due to the presence of ferrous iron resulting from the dissociation of the ferric oxide. The dissociation pressure of Fe_2O_3 was investigated; it was found to be appreciable at 1,100° C., and to increase rapidly with the temperature, reaching a pressure of the order of 5×10^5 atm. at its melting point. Evidence has been obtained which indicates that Fe_3O_4 is partially soluble in Fe_2O_3, and that Fe_2O_3 is partially soluble in Fe_3O_4. From the available data a diagram for the system Fe_2O_3–Fe_3O_4 has been constructed.

The dissociation of monocalcium ferrite and dicalcium ferrite has been investigated. Below the peritectic temperatures of these compounds the oxygen pressure is infinitesimal; at higher temperatures the pressure would seem to be due to the dissociation of the Fe_2O_3 resulting from the peritectic reactions. The oxygen pressure of the ferrites falls rapidly as the FeO increases. CaO has a marked stabilising effect upon Fe_2O_3.

The Effect of Oxygen and Sulphur on Iron in Scaling.

A network structure which forms at the boundaries of either α or γ surface grains when steel is scaled is described in this paper by Mr. J. H. Whiteley. This fact was observed by the author when examining a specimen of Armco iron which had been heated in air for about 2 hours at 960° C. The section had been well etched with picric acid, and, starting at the surface, tapering veins in strong contrast penetrated a short distance into the steel. It was certain that the structure was produced during scaling, and a closer study of its formation and characteristics was undertaken. The author describes and discusses the results of this investigation.

The network structure is revealed by the usual etching reagents, including cupric, and its intensity depends, in part, upon the temperature and length of heating. The structure does not penetrate far, and is primarily due to the presence of oxygen in the scale exceeding the ferrous-oxide phase requirement. When steel is welded by wash heating, the structure is usually to be found at the weld junction. It disappears, apparently by diffusion, when heated in the absence of oxygen at the higher temperatures in both the α and γ ranges, the rate increasing with the temperature. In purer materials, such as electrolytic iron, the structure is either extremely weak or fails to appear. This variation is traced to the influence of sulphur, which causes intensification, but, along with it, other elements may also have some effect. The action of sulphur on scale intrusion at the austenite grain boundaries is also discussed. Finally, the characteristics of the structure are compared with those of the ferrite bands in the banded structure of rolled steels, and the similarity is sufficiently marked to suggest that both are due to the same cause—namely, a heterogeneous distribution of oxygen and sulphur in the metal.

Hardening of Gunmetal.—G. H. Tonamy, " Kinzoku " (The J. of Metals), 4, 363-4 (1934). By water hardening, gunmetal can possess very excellent mechanical and physical properties. When gunmetal is held at 700° C. for 2 hours and quenched in water, it shows about 30% increase of strength and elongation as compared with the original metal.

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[2] McCance, *Journal of the West of Scotland Iron and Steel Institute*, 1933-34, vol. 41, p. 1.

Business Notes and News

The Birlec-Lindberg Controller

In pursuance of their policy of making available to British users the latest development in heat-treatment technique in other countries, Messrs. Birmingham Electric Furnaces, Ltd., have acquired the sole rights in the British Isles for the Lindberg regulator. This instrument has been supplied previously only by the Lindberg Steel Treating Company of Chicago, U.S.A., but will now be manufactured and sold in England under the name "Birlec-Lindberg" Controller.

The primary function of this instrument is the provision of a simple, accurate means for regulating the heat input to furnaces heated by electricity, gas or oil. Its use, therefore, permits a high initial rate of heating to be obtained while allowing power to be reduced to any desired extent in order to minimize temperature fluctuations during "soaking" and when working at low temperatures.

The "Birlec-Lindberg" Controller is available in a number of types designed to meet every requirement and, by its use, an improved degree of control is obtained such as could be otherwise provided only by comparatively complicated and expensive electrical equipment. It is, therefore, anticipated that it will find a wide application in this country.

British Aluminium Co., Ltd.

At the recent annual meeting of the British Aluminium Co., Ltd., the chairman, Mr. R. W. Cooper, M.C., J.P., announced that the profit had increased by £70,322 to £389,178, mainly as a result of the initial benefit obtained from the reduction of prior charges, and partly to increased sales. The consumption of aluminium throughout the world expanded during 1934, and their company sold a larger tonnage than in 1932 and 1933, although the average prices realised showed a reduction. It was pleasing to be able to record even a small improvement in the home sales, but greater sales would have been possible but for foreign imports. Larger quantities of both ingot and semi-manufactured metal were imported from foreign countries in 1934, compared with 1933, and foreign competition, more especially in rolling mill products, continued throughout the year, with consequent depression of prices.

The duty on rolling mill products of aluminium had been increased from 10% to 15%, and the duty on aluminium foil had been reinstated to 20%. They were grateful for this small recognition of so important a British industry, but unfortunately the additional protection was quite inadequate and much below the duties levied by the producing countries with whom they had to compete and into whose territories it was impossible for them to enter. Subsidies by their Governments to certain foreign importers continued and varied according to import duties and rates of exchange, with the consequence that the British increase of duty had been openly referred to by those importers as making no difference to their quotation of prices materially lower than those regarded both by British producers and their customers as normal and reasonable.

Royal Patronage for Glasgow Chemical Congress

H.M. the King has conferred his Patronage on the 54th Annual Meeting and Conference of the Society of Chemical Industry, which takes place in Glasgow on July 1 to 6. This congress is one of the outstanding scientific events of the year, and brings together many scientists from all parts of the world. Among the subjects to be discussed at Glasgow in July, are the transport of food by road, rail and sea, problems of water supply, and chemical engineering in the Navy.

Jubilee Homes for Employees

The United Steel Companies, Limited, after considering the subject of the Jubilee holiday, felt that some permanent memorial of this historic event should be made. After consultation with representatives of the Works Councils of the various branch companies, and with their full agreement, it has been decided that in lieu of any holiday or holiday payments there should be established convalescent and holiday homes for employees and/or cottage homes for retired employees. The money available for the purpose will be at least £10,000 and may exceed this sum.

Vickers-Armstrong Purchase Palmer's Yard

The announcement by Sir Charles Craven, managing director of Vickers Armstrong, that his company had bought Palmer's ship-repairing yard, will do something towards increasing employment in one of the most distressed areas of the country. This announcement comes about four months after official announcement of the formation of Palmers (Hebburn) Co., Ltd.

When the entire Hebburn establishment of Palmers Shipbuilding and Iron Co., Ltd., was acquired in May last year by National Shipbuilders Securities, Ltd., negotiations were immediately commenced for the formation of a new company to continue the dry-dock and engine-repairing department. These negotiations matured in November, when the registration of Palmers (Hebburn) Co., Ltd., was announced.

The board of directors of this company was made up exclusively of North-East Coast industrialists, and had as chairman Mr. F. C. Pyman, managing director of Messrs. William Gray and Co., Ltd., West Hartlepool. Mr. E. L. Champness, a former official of Palmers Shipbuilding and Iron Co., was appointed managing director, while Col. D. R. MacDonald, formerly general manager of Palmers Shipbuilding Co., also became a member of the directorate.

In a statement issued in November, the company declared: "We are starting with none of the difficulties associated with the recent financial position which handicapped the old firm during the past few years." This statement explained that while no ship construction would be undertaken, the company was prepared to accept large repair and reconstruction contracts. "It is also our intention," the statement continued, "to develop the firm's facilities for general sheet-iron work, general plumbing work, and constructional steel work."

Since its formation the company has substantially improved the facilities of the yard. The entire 1,300 ft. of river frontage has been dredged to give greater freedom for the execution of repairs afloat, while machinery from the Jarrow engine works has been transferred to strengthen the fitting shop at Hebburn for machinery repairs.

North-East Coast Institution of Engineers and Shipbuilders

Jubilee Meeting

The above Institution will celebrate the attainment of its Jubilee by a series of meetings to be held on July 16 to 19, in Newcastle-on-Tyne. A very comprehensive programme has been arranged, and invitations to participate in the Meeting on the same terms as members of the Institution have been extended to, and accepted by, the Institution of Naval Architects and the Institution of Engineers and Shipbuilders in Scotland. Official representatives will also attend the Meeting from kindred societies and allied bodies in this country and throughout the world.

Davy Bros., Ltd., of Sheffield, have secured a very important contract for the Government of the U.S.S.R. It consists of a complete forging and rolling plant for the production of tyres for railway wheels, having an output of 36,000 tons per annum. The machinery includes a 3,000-ton press, roughing and finishing mills, marking and rectifying presses, charging machines, hydraulic pumps and accumulator, etc.

Catalogues and Other Publications.

Certain elements have a considerable influence on steel; in application their primary object may be as purifying agents, or, when alloyed, to confer on the steel certain desirable qualities. Because of their usefulness in steel manufacture, these elements have an importance that is out of proportion to their volume. The functions of a number of these elements are discussed by Mr. W. F. Rowden in "Steel-making Alloys," the title of a brochure published by High Speed Steel Alloys, Ltd., Widnes, Lancashire, England, copies of which are available on application.

Ruston and Hornsby Ltd., of Lincoln, have issued an illustrated brochure, which gives several examples of the many Ruston "Economic" boiler installations in this country and abroad. The first part deals with the ordinary type designed by this firm, having a single bank of return tubes; the second part deals with the double return tube type; and in conclusion, some reference is made to the extensive works in which these boilers are built. Interested readers should obtain a copy.

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MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£77	0	0
Chinese	64	0	0
Crude		—	

BRASS.

Solid Drawn Tubes	lb.	9¼d.
Brazed Tubes	„	11¼d.
Rods Drawn	„	8¼d.
Wire	„	7¾d.
*Extruded Brass Bars	„	4¼d.

COPPER.

Standard Cash	£33	17	6
Electrolytic	37	15	0
Best Selected	36	0	0
Tough	35	10	0
Sheets	64	0	0
Wire Bars	37	5	0
Ingot Bars	38	0	0
Solid Drawn Tubes	lb.	10d.	
Brazed Tubes	„	10d.	

FERRO ALLOYS.

†Tungsten Metal Powder ..	lb.	0	3	3
‡Ferro Tungsten	„	0	3	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL 2–4% Carbon, scale 11/– per unit	ton	29	15	0
NOMINAL 4–6% Carbon, scale 7/– per unit	„	23	0	0
NOMINAL 6–8% Carbon, scale 7/– per unit	„	21	12	0
NOMINAL 8–10% Carbon, scale 7/– per unit	„	21	12	6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit ..	„	32	17	6
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	17	6
§Guar. max. 0·7% Carbon, scale 12/6 per unit ..	„	39	10	0
‡Manganese Metal 97–98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	5
§ Ferro-Vanadium 25–50%..	„	0	12	8
§ Spiegel, 18–20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/– per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	17	6
45/50% basis 45%, scale 5/– per unit	„	13	12	6
70/80% basis 75%, scale 7/– per unit	„	18	5	0
90/95% basis 90%, scale 10/– per unit	„	28	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn. ...	„	13	10	0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	15	5	0
§ Ferro-Molybdenum, Molyte	lb.	0	4	6
§ Calcium Molybdate	„	0	4	2

FUELS.

Foundry Coke—				
S. Wales	—	1	5	0
Scotland	—	1	8	0
Durham	0 19 0 to	1	2	0
Furnace Coke—				
Scotland	—	1	5	0
S. Wales	—	1	0	0
Durham	—	0	17	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£55	0	0
*Commercial Ingots	41	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards.. lb.	0	0	9
*Cored Bars „	0	0	11

LEAD.

Soft Foreign	£12	3	0
English	14	0	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	10	10	0
Best Bars	10	2	6
Common Bars	9	5	0
Lancashire—			
Crown Bars	9	12	6
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £7 10 0 to	8	0	0
Gas Strip	10	12	6
S. Yorks—			
Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	10½d.
†Sheet to 10 W.G.	„	11d.
†Wire	„	1/–
†Rods	„	11½d.
†Tubes	„	1/1½
†Castings	„	1/1

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
N.E. Coast—			
Hematite No. 1	3	8	0
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	10	0
Forge	3	6	6
Midlands—			
N. Staffs Forge No. 4	3	7	0
„ Foundry No. 3	3	11	0
Northants—			
Foundry No. 1	3	10	6
Forge No. 4	3	2	6
Foundry No. 3	3	7	6
Derbyshire Forge	3	6	0
„ Foundry No. 1	3	14	0
„ Foundry No. 3	3	11	0
West Coast Hematite	3	7	0
East „ „	3	8	0

SWEDISH CHARCOAL IRON AND STEEL.

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Pig Iron Kr. 103
Billets Kr. 240-290 £13 10 0–£16 0 0
Wire Rods Kr. 280-320 £15 15 0–£17 12 6
Rolled Bars (dead soft) Kr. 200-220 £10 12 6–£11 11 0
Rolled Charcoal Iron Bars Kr. 290 16 0 0
All per English ton. f.o.b. Gothenburg.

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Copper Clean	£27	0	0
„ Braziery	23	0	0
„ Wire		—	
Brass	18	0	0
Gun Metal	25	0	0
Zinc	9	0	0
Aluminium Cuttings	66	0	0
Lead	12	0	0
Heavy Steel—			
S. Wales	2	15	6
Scotland	2	10	0
Cleveland	2	12	0
Cast Iron—			
Midlands	2	7	6
S. Wales	2	11	0
Cleveland	2	12	0
Steel Turnings—			
Cleveland	1	15	0
Midlands	1	14	0
Cast Iron Borings—			
Cleveland	1	5	0
Scotland	1	17	6

SPELTER.

G.O.B. Official		—	
Hard	£11	10	0
English	16	0	0
India	13	5	0
Re-melted	14	10	0

STEEL.

Ship, Bridge, and Tank Plates Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland ..	8	10	0
„ „ (Marine) „ ..		—	
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester			
Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten ..	lb.	2/–
Finished Bars 18% Tungsten ..	„	2/9
Extras		
Round and Squares, ⅛ in. to ¼ in.	„	3d.
Under ¼ in. to 3/16 in.	„	1/–
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/–

TIN.

Standard Cash	£228	0	0
English	228	5	0
Australian		—	
Eastern	229	0	0

Tin Plates I.C. 20 × 14 box 18/2

ZINC.

English Sheets	£24	0	0
Rods	28	10	0
Battery Plates		—	
Boiler Plates		—	

*McKechnie Brothers, Ltd. May 14. † C. Clifford & Son, Ltd., May 14. ‡ Murex Limited, May 14.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, May 14.